



# **Principles of Functional Exercise**

**FOR PROFESSIONAL FITNESS TRAINERS  
FIRST EDITION**

**Charles DeFrancesco, NASM, NFPT  
Dr. Robert Inesta, DC, CCSp, CSCS**



# About this book

The purpose of this book is to educate personal trainers on the basic principles of functional training. This manual covers the scientific facts that are essential to truly understanding how the body functions and how it responds to exercise. Our belief is that by providing the facts, we give the student the ability to think about how the body works rather than memorize body parts and exercises. After reading this manual, the next step is to attend movement seminars and program design lectures. A great trainer constantly educates themselves to separate from the rest.

**Charles DeFrancesco** is the owner of Fit and Functional and Consultant to Pure Fitness Group with locations in Westchester and Greenwich. His company owns and operates personal training and corporate wellness programs in these facilities. Charles is also the head consultant to Westchester Sports and Wellness in Eastchester, New York and enjoys working with many local schools to assist with creating fun and effective exercise programs for kids.

Charles specializes in trainer education, functional assessments, flexibility and treatment of sports injuries. He is certified by the National Academy of Sports Medicine (NASM), National Federation of Professional Trainers (NFPT) and Equinox Fitness Group (Prenatal Certified). He has specialty certificates for Functional Exercise Specialist, Cardiac Conditions (AFPA), attended Equinox Fitness Training Institute (EFTI) and has attended and hosted numerous strength and condition seminars.

Along with these certifications, Mr. DeFrancesco is a contributing author to the NFPT Certified Personal Trainer manual (NFPT Study & Reference Manual: The Fundamentals) and has assisted NFPT with the creation of various courses to include advanced trainer workshops. Charles has also written continuing education courses approved by the American Council on Exercise (ACE) and National Academy of Sports Medicine. Charles is the Director of Continuing Education at NFPT and has been a Board member for over 4 years.

Mr. DeFrancesco is the main author of this book, Functional Foundations: The Principle of Functional Training, and has written numerous articles and presented lectures on the essentials of core rehabilitation and flexibility. Some of his work can be seen on PTontheNet and Personal Trainer Today.com. Charles' active research and implementation of rehabilitation and conditioning of himself and his clients has been essential in the prevention of injuries as well as the performance enhancement. Mr. DeFrancesco continues to work with clients and doctors from a number of different disciplines to set up programs and appropriate training staff for their respective rehabilitation facilities.

**Dr. Robert Inesta** earned his Doctor of Chiropractic degree at New York Chiropractic College, where he graduated Magna Cum Laude and was inducted into the Phi Chi Omega Honor Society. He was the recipient of the Frank DiGiacomo Technique Award for distinguished excellence in manual adjusting procedures, and the Levittown Health Center Award for distinguished excellence in diagnosis and case management.

Dr. Inesta is a certified Chiropractic Sports Practitioner and Certified Strength and Conditioning Specialist. His extensive post graduate training consists of functional rehabilitation, functional soft tissue therapy and biomechanics, clinical neurophysiology and electrodiagnosis and nutrition. He is certified provider of Active Release Techniques, Graston Technique and Kinesiotaping.

Dr. Inesta's main goal is to help his patients to reach their goals in the most efficient and effective way. He is consistently pursuing new information and treatment methods in order to provide the most cutting-edge care package.

He has worked with a wide variety of patients, including athletes at the high school, college and professional levels, post operative patients, pregnant women and children. He has lectured on topics including sports medicine, functional training, biomechanics, injury prevention and nutrition and has co-authored articles on functional training.

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# Principles of Functional Exercise

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**Authors:** Charles DeFrancesco  
Dr Robert Inesta, CSCS

**Co-Authors:** Jimmy Smith, MS, CSCS  
Scott DeBellis, MS  
Chris Mellars

**Contributions by:** Dr Louise Middaugh  
Dan Kruy, BS  
John Colaneri, BS  
Jill Messina  
Justin Petraglia  
Chris Petraglia  
Dr. Joshua Cullins, ATC

**Special thanks to** Ron Clark and the entire NFPT staff

**Illustrations by:** Jason Vega



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# CHAPTER 1

## **What is Functional Training?**

## What is Functional Training?

Today there are so many different opinions on how one should exercise. “What type of training is the best?” is the big question. “Does one perform slow or fast reps? Is a bench or a physio-ball better? One body part at a time or full body?” The answer is that everyone should be training in a manner that relates to their individual goals. There is no set routine that equally benefits everyone who does it. Performing a typical gym program of random exercises, three sets of ten, with one minute rests has benefits but will not be the most efficient way to attain your goals or address your specific needs. Training primarily with machines and not using free weights is inefficient because you are moving resistance along a fixed axis, not freely in space as the body normally functions. Machines have limited functional strength transfer to real life situations in most cases, and can actually create poor motor patterns in some people. Machines have value when integrated properly but are often misused.

Functional training is defined as movements or exercises that improve a person’s ability to complete their daily activities or to achieve a specific goal. It is not a series of exercises deemed functional by some manual. Doing movements in the gym that strengthen the muscles involved in the movements you wish to improve outside the gym is a good start. This does not mean you can simply add weight to the exact movement you wish to enhance. There is research that has proven doing this can actually be detrimental to some athletic movements. When a baseball player adds weight to his bat that can actually slow his bat speed down because the added resistance changes the forces on the joint and disrupts mechanics. All exercises have some functional value when applied correctly, this value is determined by the exercises transferable benefit outside the gym. Every exercise has a functional limitation and it is up to the trainer to understand what it is. A quality program focuses on weak areas and sets specific goals for the client. It is important to understand how to progress someone from simple smaller targeted movements to more complex multi joint movements. Training someone functionally can range from having a tennis player lunge to a chop or a body builder do a slow curl for bigger biceps; its all about the goal. Keep in mind performing complex movements before the client is ready will do more harm than good.

In order to build appropriate muscle strength, joint integrity, balance and flexibility in all planes of motion it is essential that the body is exercised in a functional manner. It is crucial to include multi-joint and multi-planar exercises, as this recruits the body’s stabilizers to synergistically facilitate movement. Doing this ensures that the nervous system is working properly and that all parts of the body are used in the appropriate manner, with the correct muscles firing at the right time. This is not to say you shouldn’t include some so called non functional exercises, including a machine or old school exercise can be beneficial, safe and fun when applied correctly. To create a functional program, a trainer must set realistic goals and understand the client’s weaknesses, daily activities and limitations.

A trainer must be able to identify postural distortions and include exercises that correct them. The trainer must put emphasis on educating the client on what movements or activities to

avoid or modify during their day. It's not what you do; it's how you do it. The ability to identify a postural distortion is dependent on the trainer's understanding of anatomy, motor patterns and muscle function. A trainer must also be able to identify when muscles are over active and firing out of sequence, or not firing at all. Synergistic dominance is common in most postural dysfunctions. In general, if the agonist is tight then the antagonist is weak, thus creating increased stress on the joint. This can result in patterns of repetitive stress, ultimately leading to accelerated joint degeneration.

Core stability, flexibility and balance are key factors when designing a functional exercise routine. It is important to maintain posture while being able to move all joints in a full range of motion. Training with free weights, and challenging the surrounding environment promotes balance and stability, which is necessary if you expect to see benefits outside of the gym. Keep in mind, it is more important to be able to control your own body weight and concentrate on form, balance and core endurance, than to move heavy weights.

A functional core routine consists of dynamic movements, isometric exercises and challenges the center of gravity. To completely train the core, you must also include dynamic stabilization, isometric and proprioceptive movements, not just for the mid section, but for the entire trunk. Medicine balls, balance boards, foam rollers and physio-balls are great tools for core training, and should be integrated into your programs but not over done. As a person ages, balance and stability become compromised. If balance and stability are not addressed, they will consistently degrade. A weak core contributes to poor stability, and inhibits proper limb movements, causing muscle imbalances in the kinetic chain. This is why falls are common in the geriatric population. Many back and hip injuries are related to weak core muscles. There are many small muscles in the core that the general population knows little about or addresses during exercise. In most spinal injuries, MRI images show atrophy in these small muscles. In order to maintain a healthy spine, these little muscles need to be trained. Without stability, even the strongest person can not effectively propel a force into the environment.

Flexibility is a very important facet of any exercise program, but is often over looked. Lack of flexibility in the right places appears to be the root of many problems. The body's movements are hampered when flexibility and posture are distorted. Active, dynamic, static and PNF stretching are key factors and should all be included in any training program. When a muscle is tight, it limits the muscle's ability to contract properly, causing inefficient movements and risk of injury. Without flexibility, the body's movement becomes limited, and good results are difficult to achieve.

This has explained the key components of a functional program and its benefits. Before initiating any exercise program, one should always consult a physician, as well as a qualified fitness professional. This insures that they are addressing their specific needs and goals

## Pain Related to Daily Activities?

Our daily activities can actually cause muscle imbalances. No matter what your line of work, you probably have some type of routine consisting of repetitive activities. This can overwork some muscles and under-work others. This is one reason why many people often say, “I do not know how this happened – one day I felt pain, but I’ve never had an injury.” The body is a balanced system of levers, and disrupting that balance can put joints at a mechanical disadvantage, causing unnatural and inefficient movements. The muscles that work harder tighten, while the opposite weaker muscles lengthen, causing impingement of joint spaces and other joint irregularities. This extra wear on the joints and ligaments can also cause arthritis, bulging disks and even tiny fractures in the spine. For example, an office worker who sits incorrectly all day with chin forward, shoulders rounded and leaning over toward the computer will likely have anterior shoulder, low back and neck pain. Think about the amount of times you get up and down in one day. If you are doing so incorrectly, the force on your spine eventually will cause some type of break down. This postural distortion can cause all sorts of problems, such as pain, poor sleep, scar tissue build up and muscle atrophy, just to name a few. Simply taking medication for pain is not enough and routine, impersonal, everyday exercises do not work.

Unfortunately, medication can often be a mask that only exaggerates the problem and introduces new side effects. A general exercise routine doesn’t fit every person because people have varying lifestyles and do different things. One person may have back pain due to a hip dysfunction, while another may have a thoracic issue; therefore, exercises need to be tailored to the individual. An effective exercise prescription needs to, not only consider your job, but your daily activities and workout routine. Did you know that stretching alone can alleviate many basic everyday complaints? Exercise and stretching related to daily activities can benefit any person because if you feel better at work, you will perform better. If a job is stressful it can actually cause tension in the neck and back, and pain from tight muscles can trigger stress and thus, the start of a cycle.

A functional program that considers these issues will definitely help your client. Take into consideration what they do all day, and include exercises to offset those repetitive motions or positions. It is not all about big muscles. Help your clients to feel better and they will value your service.

## Frequently Asked Questions

**Q)** Should I do slow or fast repetitions?

**A)** The speed of the repetitions should be based on the speed of the required activity. The body needs to be trained at the same, or a higher velocity during exercise to benefit a particular activity. A sprinter doesn't jog to increase their speed. Slow training is good for form training, rehabilitation and hypertrophy.

**Q)** My friend works out at the local gym and mostly uses machines. He has been doing the same routine forever and has had good results. Is this program good for me?

**A)** NO! If you stick to it, any exercise program will produce results whether it is done right or wrong. Unfortunately when exercise is done incorrectly, the harmful effects may not be noticed until the damage is done. By exercising functionally, you will systematically attain your goals and insure that your time in the gym is spent safely and efficiently. Just because someone looks good does not mean they are an expert.

**Q)** Can functional training benefit anyone?

**A)** Yes. Functional workouts are beneficial for any athletic level or age group. When you train in this fashion, you will see drastic improvement in overall health and performance not just appearance.

**Q)** Shouldn't I do cardio and lose weight before I start a functional program?

**A)** NO!

You should have a functional training program that concentrates on raising and lowering your heart rate. The program should first use body weight exercises, then advance to free weights. This promotes lean muscle mass, skeletal integrity, and healthy cardiac function. Muscle mass accelerates fat loss.

**Q)** My friend tells me to do three to five sets of 10-12 repetitions to failure, with one minute rest intervals.

**A)** This is what everyone who thinks of the gym envisions. This is not a good program unless you are a body builder. If you train in a functional fashion you burn more calories and get more benefit from your sessions outside of the gym.

**Q)** Aren't aerobic classes and the treadmill enough?

**A)** NO! A weight training program that includes balance, core stability strength and cardiac conditioning builds lean muscle mass. When you build muscle, you burn more calories at rest and during your daily activities. Therefore, by adding resistance to your program, you will actually will burn more calories doing the same aerobic class or distance on the treadmill.

**Q)** Should I stretch before or after exercise or an event?

**A)** Evidence demonstrates that static stretching before an activity is not beneficial to prevent injury. If you want to avoid injury you need to be flexible by doing regular stretching – not just before activity. Active and dynamic stretches, with a short warm up mimicking the activity before, with PNF and static stretching at the end help remove waste from the muscles.

**Q)** Why have none of my doctors told me to stretch and exercise to alleviate pain?

**A)** Unfortunately we live in a society where some doctors prescribe medications for everything imaginable. Everyone wants immediate gratification (a pill) not a long term solution (exercise). The fact is most people ignore the doctors' requests to stretch and exercise. Most minor health problems can be eliminated by moderate exercising but people choose to take medications because it is easier.

**Q)** I injured my knee and my doctor told me to rest it for a while. Do I?

**A)** So long as the joint is stable, this is the worst thing you can do. Pampering a stable injury for extended periods causes muscle atrophy and decreased blood flow. All injuries should be functionally rehabilitated under careful supervision by a health professional. There are doctors that base their whole practice on movement therapies for injuries, find them. Keep in mind there are injuries that rest is the only answer.

**Q)** Should I cut carbohydrates out of my diet?

**A)** NO! Only cut out high, glycemic carbohydrates. Carbohydrates are essential for cellular function. Eating carbohydrates that do not spike insulin levels is healthy and effective for weight loss.

**Q)** My doctor told me to walk to get some exercise for my aches. Is walking enough?

**A)** NO WAY! If walking were enough, everyone would be healthy as we all walk. If you have pain chances are there is a biomechanical issue. My first suggestion would be to stretch. More walking may further aggravate the issue; you need to correct the imbalance first, not just walk more. I suggest seeing a Physical Therapist for this situation if stretching doesn't help.

## CHAPTER 1

1. You should mostly \_\_\_\_\_ when designing your program.
  - A. Use machines
  - B. Use free weights
  - C. Focus on goal oriented exercises
  - D. None of the above
2. You should train athletes based on movements performed in the sport only?
  - A. True
  - B. False
3. If a person has a very weak core in most cases it will create a postural distortion?
  - A. True
  - B. False
4. Flexibility is an important part of every program?
  - A. True
  - B. False
5. You should take into account what your client does all day long when designing their program?
  - A. True
  - B. False
6. For a program to be considered functional it must be
  - A. Goal oriented
  - B. Relate to each client's needs
  - C. Target faulty movements patterns
  - D. All of the above





# CHAPTER 2

## Anatomy

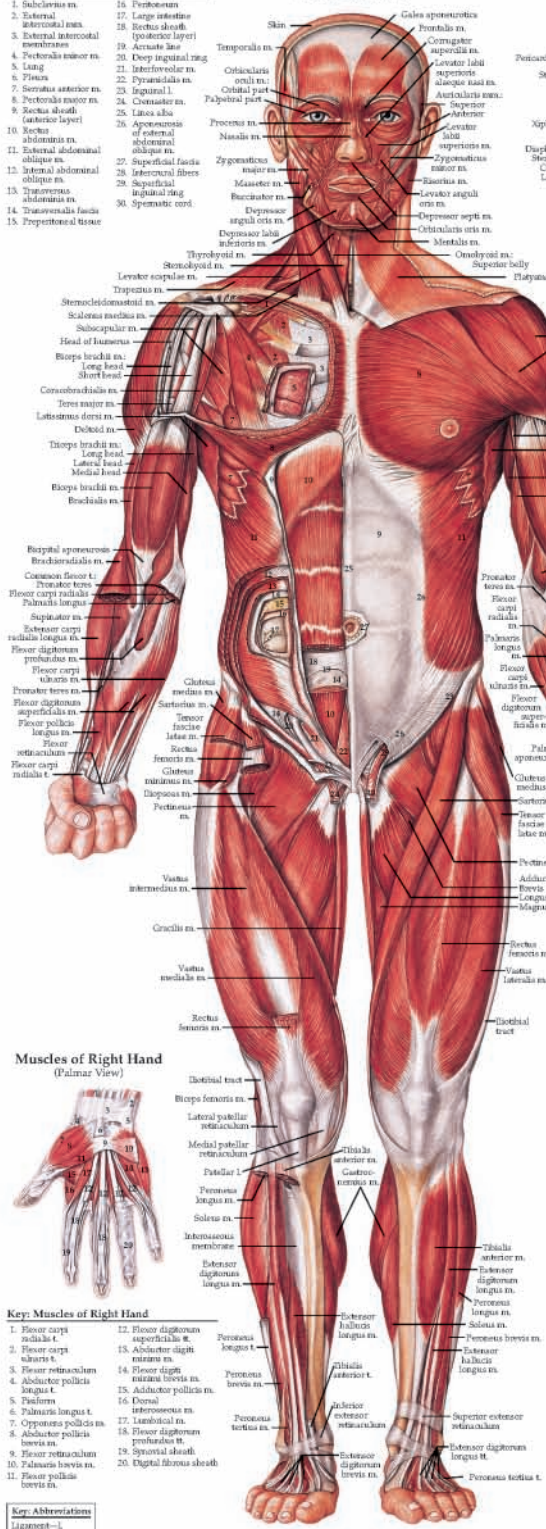
*This section is only meant as a quick anatomy reference.  
We suggest *Kinetic Anatomy* by Robert S. Behnke  
*Strength Training Anatomy* by Frederick Delavier  
or online [winkingskull.com](http://winkingskull.com)*

# THE MUSCULAR SYSTEM

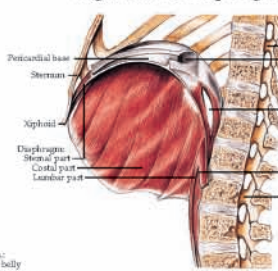
## Key: Muscles of Anterior Torso

1. Subclavius m.
2. External intercostal m.
3. External internal intercostal m.
4. Pectoralis minor m.
5. Lung
6. Pectoralis major m.
7. Serratus anterior m.
8. Pectoralis major m.
9. Rectus abdominis m.
10. Rectus abdominis m.
11. External abdominal oblique m.
12. Internal abdominal oblique m.
13. Transversus abdominis m.
14. Preperitoneal tissue
15. Peritoneum
16. Large intestine
17. Rectus abdominis (posterior layer)
18. Acromioclavicular lig.
19. Deep inguinal ring
20. Intercostal vein
21. Intercostal vein
22. Pyramidalis m.
23. Inguinal l.
24. Cremaster m.
25. Linea alba
26. Aponeurosis of external oblique m.
27. Superficial fascia
28. Intercostal fibers
29. Superficial inguinal ring
30. Spermatic cord

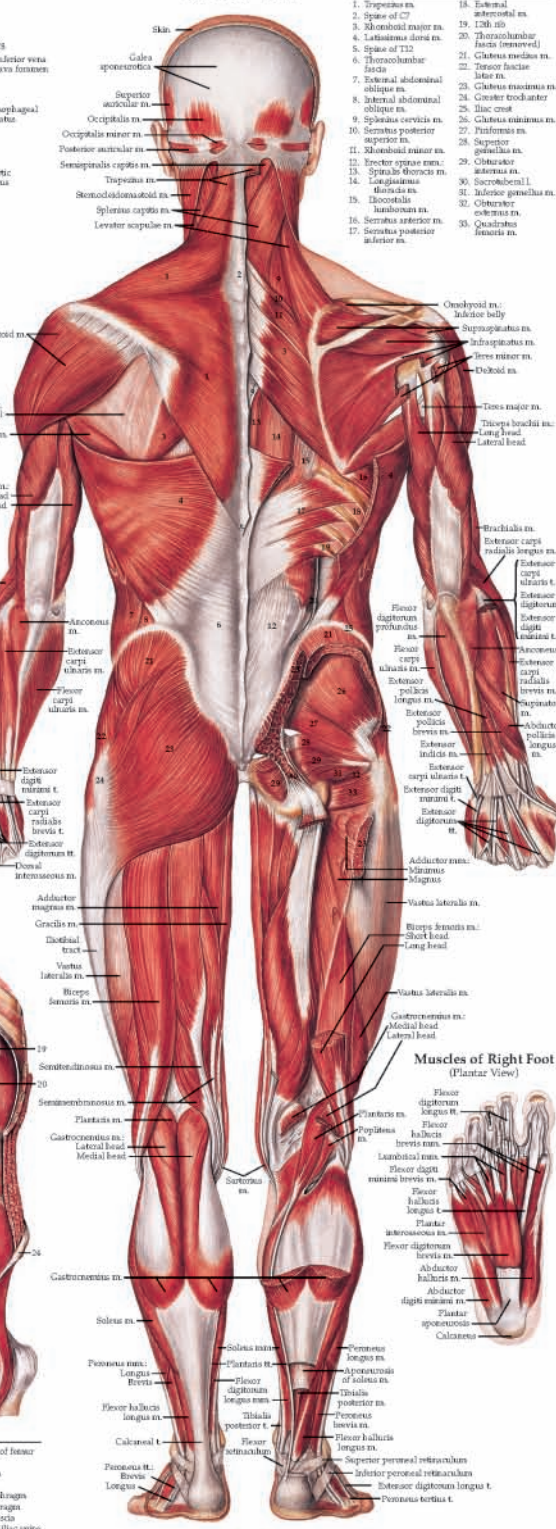
## Anterior View



## Right Half of Diaphragm



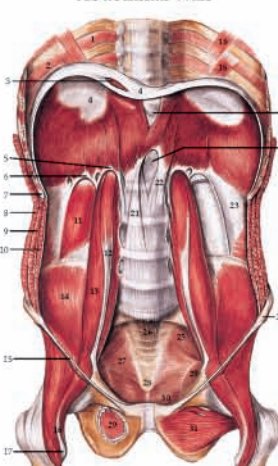
## Posterior View



## Key: Muscles of Posterior Torso

1. Trapezius m.
2. Spine of C7
3. Rhomboid major m.
4. Latissimus dorsi m.
5. Spine of T12
6. Thoracolumbar fascia
7. External abdominal oblique m.
8. Internal abdominal oblique m.
9. Serratus cervicis m.
10. Serratus posterior m.
11. Rhomboid minor m.
12. Erector spinae m.
13. Spinal thoracis m.
14. Latissimus m.
15. Erector m.
16. Serratus anterior m.
17. Serratus posterior inferior m.
18. Intercostal m.
19. C20
20. Thoracolumbar fascia (removal)
21. Clavus m.
22. Tector fasciae m.
23. Clavus m.
24. Greater trochanter m.
25. Iliac crest
26. Clavus m.
27. Piriformis m.
28. Superior gluteus m.
29. Gluteus m.
30. Sacrospinous l.
31. Inferior gluteus m.
32. Obturator externus m.
33. Quadratus femoris m.

## Muscles of Posterior Abdominal Wall



## Key: Posterior Abdominal Muscles

1. External intercostal m.
2. Internal intercostal m.
3. Inferior vena cava foramen
4. Central t. of diaphragm
5. Medial arcuate l.
6. Lateral arcuate l.
7. 12th rib
8. External abdominal oblique m.
9. Internal abdominal oblique m.
10. Transversus abdominis m.
11. Quadratus lumborum m.
12. Psoas minor m.
13. Psoas major m.
14. Iliacus m.
15. Inguinal l.
16. Biceps m.
17. Lesser trochanter of femur
18. Subcostal m.
19. Esophageal hiatus
20. Aortic hiatus
21. Right crus of diaphragm
22. Left crus of diaphragm
23. Thoracolumbar fascia
24. Anterior superior iliac spine
25. Piriformis m.
26. Sacrus
27. Coccyx m.
28. Coccyx
29. Obturator foramen m.
30. Levator ani m.
31. Obturator externus m.

## Muscles of Right Hand (Palmar View)



## Key: Muscles of Right Hand

1. Flexor carpi radialis l.
2. Flexor carpi radialis m.
3. Flexor carpi ulnaris m.
4. Abductor pollicis longus m.
5. Palmaris longus m.
6. Palmaris longus m.
7. Opponens pollicis m.
8. Abductor pollicis brevis m.
9. Flexor retinaculum
10. Palmaris brevis m.
11. Flexor pollicis longus m.
12. Flexor digitorum superficialis m.
13. Abductor digiti minimi m.
14. Flexor digitorum profundus m.
15. Adductor pollicis m.
16. Interosseus m.
17. Lumbalis m.
18. Flexor digitorum profundus m.
19. Spinalis m.
20. Digital fibrous sheath
21. Peroneus longus m.
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## Key: Abbreviations

- Ligament—l.
- Ligaments—ll.
- Muscle—m.
- Muscles—mm.
- Tendon—t.
- Tendons—tt.
- Venous—v.
- Cervical—c.
- Thoracic—t.
- Lumbar—l.

## Muscles of Right Foot (Plantar View)



## Key: Muscles of Right Foot

1. Flexor digitorum profundus m.
2. Flexor digitorum profundus m.
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83. Flexor digitorum profundus m.
84. Flexor digitorum profundus m.
85. Flexor digitorum profundus m.
86. Flexor digitorum profundus m.
87. Flexor digitorum profundus m.
88. Flexor digitorum profundus m.
89. Flexor digitorum profundus m.
90. Flexor digitorum profundus m.
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96. Flexor digitorum profundus m.
97. Flexor digitorum profundus m.
98. Flexor digitorum profundus m.
99. Flexor digitorum profundus m.
100. Flexor digitorum profundus m.

## Biomechanical Movement

- **Flexion** - bending of a joint that decreases the angle.
- **Extension** - straightening of a joint that increases the angle.
- **Hypoextension** - less extension than normal.
- **Hyperextension** - extension beyond normal limits.
- **Abduction** - away from the body.
- **Adduction** - toward the body.
- **Pronation** - palm turning down.
- **Supination** - palm turning up.
- **Rotation** - around an axis.
- **Circumduction** - circular movement.
- **Protraction** - forward motion, occurs at glenohumeral joint.
- **Retraction** - backward motion, occurs in the glenohumeral joint.
- **Internal rotation** - while rotating on its own long axis, the anterior surface moves towards the midline.
- **External rotation** - while rotating on its own long axis, the anterior surface moves away from the midline.
- **Elevation** - moving or lifting and body part in a superior direction.
- **Depression** - moving a body part in an inferior direction.
- **Dorsiflexion** - (ankle) pointing foot up towards body.
- **Plantarflexion** - (ankle) pointing foot down.
- **Inversion** - turning feet inward so the soles face each other.
- **Eversion** - turning the soles outward.
- **Gliding** - movement of non-angular joints over each other.
- **Deviation** - departure from the midline.

## **CHEST**

### **Pectoralis Major** (Clavicular)

#### **Joint Action** of the **Shoulder** (glenohumeral)

1. Horizontal adduction
2. Internal Rotation
3. Adduction
4. Flexion
5. Abduction

Example – Brings the arm across the body. Pushes forward (Protraction)

**Origin** – Clavicle (Anterior) at the medial half

**Insertion** – Humerus (Proximal and Anterior) located within the intertubercular groove

Sports associated with these movements include gymnastics and swimming

Weight training movements include but are not limited to Chest press, dumbbell flies, Lat. Pulldowns

**Common distortions due to tightness** include an internally rotated humerus contributing to scapular fixation while abducting.

## **PECTORALIS MINOR**

#### **Joint action** of the **Scapula**

1. Abduction
2. Downward rotation (during abduction)
3. Depression

#### **Joint Action** of the **Ribs**

1. Elevation.

For example it pulls coracoid process of scapula inferiorly.

**Origin** – Ribs (3rd to 5th Vertebrae) along the anterior surface

**Insertion** – Scapula (superior anterior) attaches to coracoid process (medial border)

Sports associated with these movements are climbing and gymnastics

Weight training exercises commonly associated are dips and Lat. Pulldowns.

**Common distortions caused by tightness** include a scapula that is abducted, depressed, and protracted. The combination of these three may cause impingement of the brachial plexus and axillary artery, resulting in negative arm and hand symptoms

## **STERNAL**

**Joint Action of the Shoulder** (glenohumeral)

1. Horizontal Adduction
2. Internal Rotation
3. Adduction
4. Extension

**Joint Action of the Scapula** (assisting the shoulder)

1. Downward rotation
2. Depression
3. Abduction (Initially)

An example of the scapula assisting the shoulder in its movement pattern is pulling of the arm from above the head down to a horizontal position.

**Origin** – Sternum (Anteriorly) located between the 2nd and 6th Rib vertebrae. It is comprised of Costal cartilage.

**Insertion** – Humerus (proximal anterior) is located within the Intertubercular groove.

**Common distortions caused by tightness** assists in the development of an internally rotated humerus which is a primary contributing factor to scapular depression.



## **SERRATUS ANTERIOR**

### **Joint Action of the Scapula**

1. Protraction
2. Abduction
3. Scapular stabilizer (fastens medial border to rib cage)

**Origin** – Rib surface located at upper 8th or 9th vertebrae

**Insertion** – Scapula at the anterior surface and medial border.

**Common distortions caused by weakness** are winging of medial border of scapula and shortness of the rhomboid muscles.

## **BACK**

### **Latissimus Dorsi**

**Joint Action** performed by the **Shoulder** (glenohumeral)

1. Adduction
2. Extension
3. Internal Rotation
4. Horizontal Abduction

**Joint Action** performed by the **Scapula** (assists)

1. Depression
2. Downward rotation
3. Adduction

**Joint Action** performed by **Trunk**

1. Unilaterally: Laterally flexes trunk
2. Bilaterally: anteriorly tilts pelvis

For example the pulling down of your arm from above your head brings the shoulder blades (scapular) together. The ability to pull the body up and forward when hanging from the arms is also an example.

- Origin:**
1. Ilium
  2. Posterior crest
  3. Sacrum (posterior)
  4. Vertebral Column (lateral surface): Lumbar Vertebrae (L1-5), Thoracic vertebrae (T7-12), Ribs (posterior, Lower 3 or 4 ribs)

**Insertion :** Humerus (proximal anterior/medial)

1. Intertubercular groove

Sports associated with but limited to major contribution of your back are gymnastics, swimming, climbing, Weight training – chin ups, Lat. Pulldowns.

**Common Distortions caused by tightness** is an Internally rotated humerus, Protracted scapula, and Lumbar hyperextension

## **TERES MAJOR**

**Joint Action** performed by the **Shoulder** (glenohumeral)

1. Internal Rotation
2. Extension
3. Adduction

An example would be assisting in drawing the arm back and inward.

- Origin:**
1. Scapula (posterior, inferior)
  2. Inferior angle (posterior, lateral)

**Insertion:** Humerus (proximal anterior/medial)

1. Intertubercular groove

Sports associated but not limited to the use of the Teres Major are rowing, cross country skiing. Weight training – seated row, Lat. Pulldown

**Common Distortions caused by tightness** is a laterally rotated scapula



## **TRAPEZIUS (LOWER FIBERS)**

**Joint Action** performed by the **scapula** (scapular stabilizer)

1. Upper rotation
2. Adduction
3. Depression

**Joint Action** performed by **Thoracic Spine**

1. Extension

**Origin:** Spine – 1. Thoracic Vertebrae (T4-12) – Spinous Processes

**Insertion:** 1. Scapula – Spine (inferior)

## **TRAPEZIUS (MIDDLE FIBERS)**

**Joint Action** performed by the scapula

1. Retraction (adduction)
2. Elevation
3. Upward Rotation

For example the squeezing together of the scapulars acts as a scapular stabilizer

**Origin:** 1. Cervical vertebrae (C7) – Spinous Process 2. Thoracic vertebrae (T1-T3) – Spinous Processes

**Insertion:** 1. Scapula – Acromion process, Spine (superior)

**Common distortions due to weakness** is scapular protraction and elevation (this contributes to poor glenohumeral mechanics and rotator cuff dysfunction)

## **TRAPEZIUS (UPPER FIBERS)**

**Joint Action** of the **scapula**

1. Elevation

## **Joint Action** of the **Spine** (cervical)

1. Extension
2. Lateral flexion
3. Contralateral rotation

The joint actions of the scapula and spine contribute to the ability of the head to rotate laterally as well as flex forward and extend back.

**Origin:** Skull (posterior inferior)

1. Superior nuchal line (medial third)
2. Occipital protuberance (external)
3. Ligamentum nuchae (posterior neck ligaments)

**Insertion:** Clavicle – Lateral third (posterior)

**Common distortions due to tightness:** 1. Elevated shoulder girdle 2. Early activation during humeral abduction (this contributes to poor glenohumeral mechanics and rotator cuff dysfunction.) This muscle is often overworked in weight training programs with exercises such as shrugs. It is important that the middle and lower fibers are worked equally, if not more, in order to establish scapular stabilization.

## **LEVATOR SCAPULAE**

**Joint Action** performed by the **scapula**

1. Elevation
2. Downward rotation
3. Abduction

**Joint Action** performed by the **Cervical spine**

1. Lateral flexion to the same side
2. Right rotation (right levator scapulae)
3. Left rotation (Left levator scapulae)

For example when carrying a weight the Trapezius stabilizes the scapula

**Origin:** Cervical Vertebrae (upper C3 or 4) – Transverse Process

**Insertion:** Scapula – Medial border (superior angle)

**Common distortions caused by tightness:** 1. Elevated shoulder girdle  
2. Over-worked with Upper Trapezius

## **RHOMBOID MAJOR**

**Joint Action** performed by the **scapula**

1. Adduction
2. Downward rotation

For example it assists the trapezius when moving upper extremity to stabilize scapula

**Origin:** Thoracic Vertebrae (T2-T5) – Spinous Process

**Insertion:** Scapula – Medial border (below spine)

**Common distortions due to tightness** is a protracted Scapula

## **RHOMBOID MINOR**

**Joint Action** performed by the **scapula**

1. Adduction
2. Downward rotation

For example it assists the middle trapezius when moving upper extremity to stabilize scapula

**Origin:** 1. Cervical Vertebrae (C7) – Spinous Processes  
2. Thoracic Vertebrae (T1) – Spinous Processes

**Insertion:** Scapula – Medial Border (at level of the spine)

**Common distortions caused by weakness** is a protracted scapula

## **Erector Spinae**

- |                          |             |             |             |
|--------------------------|-------------|-------------|-------------|
| <b>I. Iliocostalis</b> – | 1. Lumborum | 2. Thoracis | 3. Cervicis |
| <b>II. Longissimus</b> – | 1. Thoracis | 2. Cervicis | 3. Capitis  |
| <b>III. Spinalis</b> –   | 1. Thoracis | 2. Cervicis | 3. Capitis  |

**Joint Action** performed by **Lumbar/Thoracic Spine**

1. Extension (I,II,III)
2. Lateral flexion (I)
3. Rotation (I)

## Joint Action performed by **Cervical spine**

1. Extension (I,II,III)
2. Lateral flexion (I,II)
3. Rotation (I,II)

## Joint Action performed by **Upper cervical** (Atlantoccipital & Atlantoaxial)

1. Extension – Both sides (II,III)
2. Rotation – A. Rotation right (right II, III) B. Rotation left (Left II, III)
3. Lateral Flexion – A. Lateral flexion right (right II,III) B. Lateral Flexion left (left II,III)

**Origin:** 1. Sacrum – Posterior surface (I)  
2. Ribs – posterior (I)  
3. Lumbar vertebrae (Transverse process (II)  
4. Thoracic vertebrae - Transverse processes (II, III)  
5. Cervical vertebrae – Transverse Processes (III)  
6. Ligamentum Nuchae (III)

**Insertion:** Ribs – 1. Posterior (I)  
2. Cervical vertebrae – A. Transverse processes (I,II) B. Spinous processes (III)  
3. Thoracic vertebrae – A. Transverse processes (II) B. Spinous Processes (III)  
4. Skull – A. Mastoid Processes (II) B. Occipital bone (III)

**Common distortions caused by tightness** are hyperextensions of the back and neck vertebrae.

## SHOULDER

### Anterior Deltoid

**Joint Action** performed by the **Shoulder** (glenohumeral)

1. Abduction
2. Flexion
3. Horizontal Abduction
4. Internal Rotation

For example the anterior deltoid allows the raising your arm in front of you (flexion)

**Origin:** Clavicle – anterior lateral third

**Insertion:** Humerus (lateral) - Deltoid tuberosity

**Common distortions caused by tightness** is an internally rotated humerus

## **MIDDLE DELTOID**

**Joint Action** performed by the **Shoulder** (glenohumeral)

1. Abduction
2. Horizontal Abduction
3. Flexion

For example it allows the raising of the arm out to the side.

**Origin:** Scapula – Acromion (lateral)

**Insertion:** Humerus (lateral – Deltoid tuberosity)

## **POSTERIOR DELTOID**

**Joint Action** performed by the **Shoulder** (glenohumeral)

1. Extension
2. Horizontal Abduction
3. External Rotation

For example it allows for the arm to be raised to the back

**Origin:** Scapula – spine (inferior edge)

**Insertion:** Humerus (lateral) – Deltoid tuberosity

**Common distortions caused by tightness** (all fibers) is an elevated humerus and the weakening of the supraspinatus and impingement of the supraspinatus tendon.

## **ROTATOR CUFF**

**Infraspinatus**

**Joint Action** performed by the Shoulder (glenohumeral)

1. External Rotation
2. Horizontal Abduction
3. Stabilizes glenohumeral joint

For example performing external rotation in a side-lying position.

**Origin:** Scapula – Infraspinous fossa (medial)

**Insertion:** Humerus – Greater tubercle (posterior)

**Common distortions caused by weakness** are an internally rotated humerus, tennis elbow (increased use of wrist extensors to compensate for lack of external glenohumeral rotation), and Glenohumeral instability

## **SUPRASPINATUS**

**Joint Action** performed by the **Shoulder** (glenohumeral)

1. Abduction (initiates)
2. Stabilizes glenohumeral joint

For example performing shoulder abduction in a side-lying position.

**Origin:** Scapula – superior

**Insertion:** Humerus – 1. Greater tubercle (superior)  
2. Superior facet

**Common distortions caused by weakness** is an over activation of the deltoid and glenohumeral instability.

## **SUBSCAPULARIS**

**Joint Action** performed by the **Shoulder** (glenohumeral)

1. Internal Rotation
2. Stabilizes glenohumeral joint
3. Acts as a decelerator of glenohumeral joint when externally rotating

For example it decelerates glenohumeral joint during the cocking phase of overhand throwing. As well as performing internal rotation in the side-lying position.

**Origin:** Scapula (anterior) – Subscapularis fossa

**Insertion:** Humerus (proximal anterior) Lesser tubercle

**Common distortions due to weakness** include glenohumeral instability and the inability to reach behind the back

**Common distortions due to tightness** is an internally rotated humerus.

## **TERES MINOR**

**Joint Action** performed by the **Shoulder** (glenohumeral)

1. External Rotation
2. Horizontal abduction
3. Stabilizes glenohumeral joint

**Origin:** Scapula – Lateral border, Posterior on upper and middle aspect

**Insertion:** Humerus – Greater tubercle (posterior) – inferior facet

**Common distortions caused by weakness** is glenohumeral instability

## **ARM**

**Biceps Brachii** (long head)

**Joint Action** performed by the **Elbow** and **Forearm**

1. Flexion
2. Supination - respectively

For example it bends the elbow and turns palms up.

**Origin:** Scapula – Supraglenoid tubercle

**Insertion:** 1. Radius – Tubercle  
2. Fascia of forearm – Bicipital aponeurosis

The bicep tendon also assists in glenohumeral stabilization

**Common exercises** include bicep curls, Lat. Pulldowns.

**Biceps Brachii** (short head)

**Joint Action** performed by the **Elbow, Forearm**

1. Flexion
2. Supination – respectively

**Joint Action** performed by the **Shoulder** (glenohumeral)

1. Flexion (weak)
2. Horizontal Abduction (weak)

For example it bends the elbow, turns palms up and assists in bringing upper arm forwards.

**Origin:** Scapula – Coracoid process

**Insertion:** 1. Radius – Tubercle  
2. Fascia of forearm – Bicipital aponeurosis

**Common distortions due to tightness** is a protracted scapula

## **BRACHIALIS**

**Joint Action** performed by the **Elbow**

1. Flexion (primary)

**Origin:** Humerus (anterior)

**Insertion:** Ulna – Coronoid process

For example bends elbow such as doing bicep curl

## **BRACHIORADIALIS**

**Joint Action** performed by the **Elbow**

1. Flexion

For example bends elbow with thumb pointed up



**Origin:** Humerus – Lateral supracondylar ridge

**Insertion:** Radius (lateral distal) – Styloid process

For example hammer curls

**Common distortions due to tightness is tennis elbow.**

## **TRICEPS BRACHII (LONG HEAD)**

**Joint Action** performed by **Elbow and Shoulder** (glenohumeral)

1. Extension – elbow
2. Extension -shoulder
3. Adduction – shoulder

For example straightens elbow

**Origin:** Scapula – Infraglenoid tubercle

**Insertion:** Ulna (proximal posterior) – Olecranon process

## **TRICEPS BRACHII (LATERAL HEAD)**

**Joint Action** performed by **Elbow**

1. Extension (with supination of forearm)

For example straightening of the elbow with the thumb pointed out

**Origin:** Humerus (posterior) – Superior to radial groove

**Insertion:** Ulna (proximal posterior) – Olecranon process

## **TRICEPS BRACHII (MEDIAL HEAD)**

**Joint Action** performed by **Elbow**

1. Extension (with pronation of forearm)

For example straightening of the elbow with the elbow pointed in

Origin: Humerus (Posterior) – Inferior to radial groove

Insertion: Ulna (Proximal posterior) – Olecranon process

## **FOREARM**

### **Wrist Extensors**

- I. Extensor Digitorum
- II. Extensor Carpi Radialis Longus
- III. Extensor Carpi Radialis Brevis
- IV. Extensor Carpi Ulnaris
- V. Extensor Indicis
- VI. Extensor Digiti Minimi
- VII. Extensor Pollicis Longus
- VIII. Extensor Pollicis Brevis

### **Joint Action** performed by the **Wrist**

1. Extension (I,II,III,IV,V,VI,VII)
2. Abduction (II,III,VII,VIII)
3. Adduction (IV)

### **Joint Action** performed by the **Fingers**

1. Extension – A. Index(I,V) B. Middle (I) C. Ring (I) D. Little (I,VI)
2. Abduction – A. Index (I,V) B. Middle (I) C. Ring (I) D. Little (I,VI)

### **Joint Action** performed by the **Thumb**

1. Extension (VII,VIII)

### **Joint Action** performed by the **Elbow** (very weak)

1. Extension ( I,II,III,IV)

**Origin:** 1. Humerus (lateral distal) – Lateral epicondyle (I,II,III,IV,VI)  
2. Ulna (Posterior lateral) – (V,VII)  
3. Radius (medial lower middle ) – (VIII)

**Insertion:** 1. Fingers (dorsal) A. Four fingers (I) – second and third phalanges B. Index (V) – Proximal phalanx, Dorsal expansion C. Little (VI) – Proximal phalanx  
2. Thumb (dorsal) – A. Base of distal phalanx (VII) B. Base of proximal phalanx (VIII)  
3. Metacarpals (dorsal) A. Second (II) B. Third (III) C. Fifth (IV)

**Common distortions due to tightness** include tennis elbow (lateral epicondylitis) due to overuse. This may be due to excessive repetitive wrist extension in order to compensate for lack of external rotation in the glenohumeral joint (common in racquet sports).

## **WRIST FLEXORS**

- I. Flexor digitorum superficialis
- II. Flexor digitorum profundus (four heads)
- III. Flexor carpi radialis
- IV. Flexor carpi ulnaris
- V. Palmaris longus
- VI. Flexor pollicis longus

### **Joint Action** performed by the **Wrist**

1. Flexion (I,II,III,IV, V, VI)
2. Abduction (III)
3. Adduction (IV)

### **Joint Action** performed by the **Fingers**

1. Flexion (I,II)
2. Adduction (I,II)

### **Joint Action** performed by the **Thumb**

1. Flexion (VI)

### **Joint Action** performed by the **Elbow** (very weak)

1. Flexion (I,III,IV,V)

**Origin:**

1. Humerus (medial distal) – Medial epicondyle (I,III,IV,V)
2. Ulna – A. Medial coronoid (I) B. Proximal  $\frac{3}{4}$  (anterior & medial) (II)  
C. Proximal posterior (IV)
3. Radius (middle anterior) (I,VI)

**Insertion:**

1. Fingers (palmer surface) A. Sides of middle phalanges (I) B. Base of distal phalanges (II)
2. Thumb (palmer surface) – Base of distal phalanx (VI)
3. Metacarpals - A. Second & third (III) B. Fifth (IV) C. Second, third, fourth, fifth.  
\*Palmer aponeurosis (V)\*
4. Carpals (medial) (IV) – A. Pisiform B. Hamate

**Common distortions due to tightness** is a median and ulnar nerve entrapment. It is important to assess these muscles, along with other soft tissues in the forearm and wrist, with carpal tunnel syndrome.

## **PRONATOR TERES**

**Joint Action** performed by the **Forearm**

1. Secondary pronator
2. Flexes

For example it turns the palm of the hand downward

**Origin:** 1. Humerus – Medial epicondyle  
2. Ulna – Coronoid process

**Insertion:** Radius (midway along lateral aspect)

**Common distortions due to tightness** is a median nerve entrapment mimicking or contributing to carpal tunnel syndrome

## **PRONATOR QUADRATUS**

**Joint Action** performed by the **Forearm**

1. Primary pronator

For example it helps to turn the palm down

**Origin:** Ulna – Anterior aspect of distal quarter

**Insertion:** Radius - Anterior aspect of distal quarter

**Common distortions due to tightness** is a lateral epicondylitis caused by overloading of the supinator

## **SUPINATOR**

**Joint Action** performed by the **Forearm**

1. Supinates – turning palming up

**Origin:** 1. Humerus – Laterl epicondyle  
2. Ulna – Supinator crest \*Radial Collateral Ligament\*

**Insertion:** Radius – Proximal third (lateral aspect)

**Common distortions due to tightness** include Lateral epicondylosis and radial nerve entrapment

## **LOWER EXTREMITY**

### **Adductor Brevis**

**Joint Action** performed by the **Hip**

1. Adduction
2. Horizontal Adduction – bringing thighs together
3. Flexion (initial)

**Origin:** Pubis

**Insertion:** Femur (medial) – A. Lesser trochanter B. Linea aspera

## **ADDUCTOR LONGUS**

**Joint Action** performed by the **Hip**

1. Adduction
2. Horizontal Adduction
3. Flexion (initial)

**Origin:** Pubis

**Insertion:** Femur (medial) – Linea aspera

## **ADDUCTOR MAGNUS**

**Joint Action** performed by the **Hip**

1. Adduction
2. Horizontal adduction
3. Extension
4. External rotation (during adduction)

**Origin:** 1. Pubis  
2. Ischium

**Insertion:** Femur (medial) – A. Linea aspera 2. Medial condyle (adductor tubercle)

## **GRACILIS**

**Joint Action** performed by the **Hip**

1. Adduction
2. Horizontal adduction

**Joint Action** performed by the **Knee**

1. Flexion

**Origin:** Pubis – A. Body 2. Inferior ramus

**Insertion:** Tibia (superior) – Medial surface

**Common distortions due to tightness** (all adductors) is excessive hip adduction during gait. This will increase stress on the abductor muscles in order to hold the leg straight. It creates medial force on the knee, causing medial buckling.

## **PSOAS MAJOR**

**Joint Action** performed by the **Hip** and **Spine**

1. Flexion
2. Spine (thoracic & lumbar) – lateral flexion

For example the hip and spine combined bring thigh forward and up. It helps bend the trunk forward against gravity. It assists with adduction, external rotation, and flexion of the lumbar spine.

**Origin:** Vertebrae (lateral surface ) A. Thoracic (T12) B. Lumbar (L1-L5) C. Intervertebral discs

**Insertion:** Femur – Lesser Trochanter

**Common distortions caused by tightness** include restriction of hip extension, hyperextension of lumbar spine, and flexion of hips and trunk. Exercises such as sit-ups and leg lifts usually emphasize these muscles over the abdominal muscles. Iliopsoas is commonly referred to as one muscle, however, they are two separate muscles working synergistically (Psoas and Iliacus)

## ILIACUS

**Joint Action** performed by the **Hip** and **Spine**

1. Flexion
2. Spine (thoracic & lumbar) – lateral flexion

For example the hip and spine combined bring thigh forward and up. It helps bend the trunk forward against gravity. It assists with adduction, external rotation, and flexion of the lumbar spine when femur is stabilized

**Origin:** Iliac fossa to the tendon of the Psoas Major

**Insertion:** Femur – Lesser Trochanter

**Common distortions caused by tightness** include restriction of hip extension, hyperextension of lumbar spine, and flexion of hips and trunk. Exercises such as sit-ups and leg lifts usually emphasize these muscles over the abdominal muscles. Iliopsoas is commonly referred to as one muscle, however, they are two separate muscles working synergistically (Psoas and Iliacus). Treat them as two muscles and you will get better results. They have different origins, but insert together on the femur

## **PECTINEUS**

**Joint Action** performed by the **Hip**

1. Adduction
2. Horizontal Adduction
3. Flexion (initial)

**Origin:** Pubis – upper border

**Insertion:** Femur – below trochanter

## **HIP EXTERNAL ROTATORS**

- I. Piriformis
- II. Gemellus Superior
- III. Obturator Internus
- IV. Gemellus Inferior
- V. Obturator Externus
- VI. Quadratus Femoris

**Joint Action** performed by the **Hip**

1. External Rotation (I,II,III,IV,V,VI)
2. Horizontal abduction (I,V)

**Origin:** 1. Sacrum – A. Anterior (I) B. Sacrotuberous ligament (I)  
2. Ischium – Posterior portions – A. Ischial spine (II) B. Ischial tuberosity C. Posterior portion (IV) D. External border (VI) E. Obturator foramen (V,VI)  
3. Ischium and pubis – inside surface and obturator membrane (III)

**Insertion:** Femur – Greater Trochanter – A. Medial surface (II,III,IV) B. Superior/medial spine (I)  
C. Posterior surface D. Quadrate tubercle (VI) E. Trochanteric fossa (V)

**Common distortions due to tightness** include restricted internal rotation of the hip, winging of the foot (toe-out) during gait, and may cause sciatic nerve impingement



**Gluteus Maximus** – I. Upper Fibers  
II. Lower Fibers

**Joint Action** performed by the **Hip**

1. Extension (I,II)
2. External rotation (I,II)
3. Horizontal abduction (I,II)
4. Adduction (II)

For example it brings the thigh back and assists in standing from a seated position.

**Origin:** 1. Ilium (I,II) – Crest (posterior)  
2. Sacrum (posterior) (I,II)  
3. Thoracolumbar fascia (I,II)

**Insertion:** 1. Femur – Fluteal line (II)  
2. Tibia – Lateral condyle – Iliotibial tract (lateral thigh) (I)

For example exercises such as squats, lunges, bridges

Common distortions due to weakness include inability to squat. Tight hamstrings and erector spinae due to overcompensation. This will lead to instability of the trunk and overloading of the facet joints in the lumbar spine.

**Gluteus Medius** – I. Anterior Fibers  
II. Posterior Fibers

**Joint Action** performed by the **Hip**

1. Abduction (I,II)
2. Horizontal Abduction (I,II)
3. Internal rotation (I)
4. External rotation (during abduction) (II)

For example it lifts leg out to the side and turns it in.

**Origin:** Ilium – External surface just below crest. A. Anterior (I) B. Posterior (II)

**Insertion:** Femur – Greater trochanter – Posterior and lateral surface (I,II)

Exercises include squats (with tubing around knees emphasizing abduction), lunges, and lateral lunges

Common distortions due to weakness include buckling knees during squats and over-adduction during gait

## **GLUTEUS MINIMUS**

**Joint Action** performed by the **Hip**

1. Abduction
2. Horizontal abduction
3. Internal rotation (during abduction)

**Origin:** Ilium – External surface (below the origin of the gluteus medius)

For example lifts leg out to the side and turns it inward

**Insertion:** Femur – Greater trochanter – Anterior surface

Exercises include squats (with tubing around knees emphasizing abduction), lunges, and lateral lunges

**Common distortions due to weakness** are buckling knees during squats and over-adduction during gait

## **TENSOR FASCIAE LATAE**

**Joint Action** performed by the **Hip**

1. Abduction
2. Flexion
3. Internal rotation

**Joint Action** performed by the **Knee** (via iliotibial band)

1. Assists in extension

For example kicking your leg out to the side

**Origin:** Ilium – A. Outer lip of crest B. Anterior superior iliac spine

**Insertion:** Iliotibial band (to lateral condyle of tibia)

Common distortions caused by tightness include lateral tracking of femur during hip flexion

## **SARTORIUS**

**Joint Action** performed by the **Hip**

1. Flexion
2. Abduction
3. External rotation

**Joint Action** performed by the **Knee**

1. Flexion

For example it brings the knee up and turns thigh outward (crossing legs when sitting).

**Origin:** Ilium – Iliac spine (anterior superior)

**Insertion:** Tibia – Medial condyle (anterior)

**Common distortions due to tightness** is a restriction of hip extension and internal rotation. Some sports associated with these movements include ballet, soccer, and skating

## **HAMSTRINGS**

**Biceps Femoris** (Long Head)

**Joint Action** performed by the **Knee**

1. Flexion
2. External Rotation

**Joint Action** performed by the **Hip**

1. Extension

**Origin:** Ishium – Ischial tuberosity

**Insertion:** 1. Tibia – Lateral condyle  
2. Fibula – Head

## **BICEPS FEMORIS (SHORT HEAD)**

**Joint Action** performed by the **Knee**

1. Flexion
2. External rotation

**Origin:** Femur (posterior) – A. Linea aspera B. Lateral condylar ridge

**Insertion:** 1. Tibia – Lateral condyle  
2. Fibula – Head

## **SEMITENDINOSUS**

**Joint Action** performed by the **Knee**

1. Flexion
2. Internal rotation

**Joint Action** performed by the **Hip**

1. Extension

**Origin:** Ischium – Ischial tuberosity

**Insertion:** Tibia – Medial condyle

## **SEMIMEMBRANOSUS**

**Joint Action** performed by the **Knee**

1. Flexion
2. Internal rotation

**Joint Action** performed by the **Hip**

1. Extension

**Origin:** Ischium – Ischial tuberosity

**Insertion:** Tibia – Medial condyle

**Common distortions caused by tightness** is an inability to fully extend the knee, restricted internal rotation of the hip, a weakness of the gluteus maximus, and pelvic tilted posterior (this can lead to increased stress on the lumbar intervertebral discs)

## QUADRICEPS

### **Rectus Femoris**

**Joint Action** performed by the **Knee** and **Hip**

1. Extension
2. Flexion – respectively

For example it allows the knee to straighten

**Origin:** Ilium – anterior inferior iliac spine

**Insertion:** Tibia – Tuberosity – \*Patellar tendon\*

**Common restrictions due to tightness** is a restricted hip extension which causes increased load on lumbar spine. Exercises associated with these muscles are squats and lunges.

## VASTUS LATERALIS (EXTERNUS)

**Joint Action** performed by the **Knee**

1. Extension

**Origin:** Femur – Lateral surface

**Insertion:** Tibia – Tibia – tuberosity – \*Patellar tendon\*

**Common distortions due to tightness** may form adhesions with iliotibial band and lateral tracking of patella during gait.

## VASTUS INTERMEDIUS

**Joint Action** performed by the **Knee**

1. Extension

**Origin:** Femur – Anterior surface

**Insertion:** Tibia – Tuberosity – \*Patellar tendon\*

## **VASTUS MEDIALIS (INTERNUS)**

**Joint Action** performed by the **Knee**

1. Extension

**Origin:** Femur – Medial surface

**Insertion:** Tibia – Tuberosity – \*Patellar tendon\*

**Common distortions caused by weakness** include lateral tracking of patella

## **GASTROCNEMIUS – I. MEDIAL HEAD II. LATERAL HEAD**

**Joint Action** performed by the **Ankle** and **Knee**

1. Plantar flexion (I,II)
2. Flexion (I,II) – respectively

For example it pushes forefoot down and braces back of ankle. It also raises the heel while pushing off during gait

**Origin:** Femur – A. Medial condyle (Posterior, I) B. Lateral condyle (Posterior, II)

**Insertions:** Calcaneus – Achilles tendon (I,II)

**Common distortions caused by tightness** are elevated heels during a squat due to limited dorsiflexion and increased stress on calcaneus

## **SOLEUS**

**Joint Action** performed by the **Ankle**

1. Plantar flexion

**Origin:** 1. Tibia (upper posterior)  
2. Fibula (upper posterior)

**Insertion:** Calcaneus – Achilles tendon

**Common distortions caused by tightness** are elevated heels during a squat due to limited dorsiflexion and increased stress on calcaneus

## **POPLITEUS**

**Joint Action** performed by the **Tibia**

1. Flexion
2. Internal rotation (when femur is fixed)

**Joint Action** performed by the **Femur**

1. External rotation (when tibia is fixed)

**Origin:** Femur – Lateral epicondyle

**Insertion:** Tibia – posterior medial aspect

**Common distortions caused by weakness** is a hyperextended knee

**Common distortions caused by tightness** is an inability to fully extend knee and an internally rotated tibia

## **FIBULARIS (PERONEUS) LONGUS**

**Joint Action** performed by the **Foot**

1. Eversion
2. Pronation

**Joint Action** performed by the **Ankle**

1. Weak plantar flexion

For example it points the foot down and out

**Origin:** 1. Tibia – Lateral condyle  
2. Fibula – A. Head B. Proximal two thirds C. Deep fascia

**Insertion:** First metatarsal – Base (lateral side) – \*Medial cuneiform\*

**Common distortions caused by tightness** is over-pronation

## **FIBULARIS (PERONEUS) BREVIS**

**Joint Action** performed by the **Foot**

1. Eversion
2. Pronation

**Joint Action** performed by the **Ankle**

1. Weak plantar flexion

**Origin:** Fibula – distal two thirds \*Intermuscular septum\*

**Insertion:** Fifth metatarsal – Base (lateral aspect)

**Common distortions caused by tightness** is over-pronation

## **FIBULARIS (PERONEUS) TERTIUS**

**Joint Action** performed by the **Ankle** and **Foot**

1. Dorsiflexion
2. Eversion – respectively

For example it points the foot up and out

**Origin:** Fibula – Distal one third \*Intermuscular septum, Interosseous membrane

**Insertion:** Fifth metatarsal – Base (dorsal aspect)



**Common distortions caused by weakness** is a foot drop

## **PLANTARIS**

**Joint Action** performed by the **Ankle** and **Knee**

1. Plantarflexion
2. Flexion – respectively

For example it points the foot down

**Origin:** Femur – A. Lateral supracondylar line (distal aspect)  
B. Popliteal surface \*Oblique popliteal ligament\*

**Insertion:** Calcaneus – Posterior aspect via Achilles tendon

**Common distortions due to weakness** is a heel which is elevated during a squat due to limited dorsiflexion and increased stress on calcaneus

## **TIBIALIS POSTERIOR**

**Joint Action** performed by the **Ankle**

1. Inversion
2. Plantar flexion (assists)

For example it points the foot down and in

**Origin:** 1. Tibia – Posterior lateral aspect  
2. Fibula – Proximal two thirds (medial aspect) \*Interosseous membrane

**Insertion:** 1. Navicular – Tuberosity  
2. Calcaneus – Sustentaculum tali (first, second, and third cuneiforms)  
3. Cuboid – bases (second, third, and fourth metatarsals)

**Common distortions due to weakness** and tightness respectively are over-pronation and supination

## **FLEXOR HALLUCIS LONGUS**

**Joint Action** performed by the **Interphalangeal** joint of **first toe, Ankle,** and **Foot**

1. Flexion
2. Dorsiflexion
3. Inversion – respectively

For example it points the big toe down

**Origin:** Fibula – Distal two thirds (posterior aspect) \* Inerosseous membrane, Intermuscular septum\*

**Insertion:** First distal phalanx – plantar surface

Common distortions caused by weakness include increased risk of hammer toe and over-pronation

**Common distortions caused by tightness** is plantar fasciitis and turf toe

## **FLEXOR HALLUCIS BREVIS**

**Joint Action** performed by the **First metatarsophalangeal joint**

1. Flexion

For example it points the big toe down

**Origin:** Cuboid – medial plantar aspect - \*Tibialis posterior tendon, Lateral cuneiform\*

**Insertion:** First proximal phalanx – Medial and lateral aspect

**Common distortions caused by weakness** is increased risk of hammer toe

## **FLEXOR DIGITORIUM LONGUS**

**Joint Action** performed by the **Second** through fifth distal **interphalangeal joint**

1. Flexion

**Joint Action** performed by the **second** through fifth **metatarsophalangeal joints**

1. Flexion

**Joint Action** performed by the **Ankle** and **Foot**

1. Plantar flexion
2. Inversion (assisted) – respectively

For example it points second through fifth toes down

**Origin:** Tibia – Posterior aspect - \*Fascia covering tibialis posterior\*

**Insertion:** Second through fifth distal phalanges – Bases

**Common distortions caused by weakness** is over-pronation

## **FLEXOR DIGITORUM BREVIS**

**Joint Action** performed by the **Proximal interphalangeal joints**

1. Flexion

**Joint Action** performed by the **Metatarsophalangeal joints**

1. Flexion (assisted)

For example it points toe down

**Origin:** Calcaneal tuberosity – Medial process - \*Plantar fascia\*

**Insertion:** Second through fifth middle phalanges

**Common distortions caused by weakness** is a lack of support for the longitudinal and transverse arches

## **QUADRATUS PLANTE**

**Joint Action** performed by the Second, third, fourth and fifth digits

1. Assists line of pull of flexor digitorum longus
2. Flexion (assists)

**Origin:** 1. Medial Head – Calcaneus (Medial aspect)  
2. Long plantar ligament (Medial aspect)  
3. Lateral Head – Calcaneus (Lateral border – plantar aspect)  
4. Long Plantar Ligament – lateral aspect

**Insertion:** Flexor digitorum longus tendon – tendon, dorsal, and plantar aspects

## **TIBIALIS ANTERIOR**

**Joint Action** performed by the **Ankle** and **Intertarsal**

1. Dorsiflexion
2. Inversion (supination) – respectively

For example it pulls the foot up and heel walking

**Origin:** Tibia – lateral

**Insertion:** 1. Tarsal – Cuneiform (medial)  
2. Metatarsal – first

Exercise for this muscle is reverse calf raise

**Common distortions due to weakness** include inability to dorsiflex, a foot drop during gait, and the inability to performed a squat without lifting heels

## **EXTENSOR DIGITORUM LONGUS**

**Joint Action** performed by the **Second** through **fifth metatarsophalangeal joints**

1. Flexion

**Joint Action** performed by **Second** through **fifth interphalangeal joints**

1. Flexion

**Joint Action** performed by the **Ankle** and **Foot**

1. Plantar Flexion
2. Eversion (assists) – respectively

For example points second through fifth toes up

**Origin:** 1. Tibia – Lateral condyle  
2. Fibula – Proximal three fourths (anterior aspect) - \*Interosseous membrane, Intermuscular septum\*

**Insertion:** Second through fifth middle and distal phalanges – Attaches via dorsal expansion hood

**Common distortions caused by weakness** is a collapse of the medial longitudinal arch and a foot drop

## **EXTENSOR DIGITORUM BREVIS**

**Joint Action** performed by **Second through fifth metatarsophalangeal joints**

1. Extension

**Joint Action** performed by the **Second through fifth interphalangeal joints**

1. Extension (assists)

For example points second through fifth toes up

**Origin:** 1. Calcaneus  
2. Lateral talocalcaneal ligament

**Insertion:** Second through fifth middle and distal phalanges – Attaches, joining extensor digitorum longus via dorsal expansion hood

**Common distortions caused by the weakness** is foot drop and collapse of medial longitudinal arch

## **EXTENSOR HALLUCIS LONGUS**

**Joint Action** performed by the **First metatarsophalangeal** and **First interphalangeal** joints

1. Extension – for both joints

**Joint Action** performed by the **Ankle** and **Foot**

1. Dorsiflexion (assists)
2. Inversion (assists) – respectively

**Origin:** Fibula – distal two thirds (anterior aspect) \*Interosseous membrane\*

**Insertion:** First distal phalanx – base

**Common distortions due to tightness** is a depression of the first metatarsal

## **EXTENSOR HALLUCIS BREVIS**

**Joint Action** performed by the **First metatarsophalangeal** joint

1. Extension

For example points big toe up

**Origin:** 1. Calcaneus – Superior and lateral aspects  
2. Lateral talocalcaneal  
3. Extensor retinaculum – Inferior

**Insertion:** First proximal phalanx – Base (dorsal surface)

**Common distortions caused by weakness** is depression of the first metatarsal

## **ABDUCTOR HALLUCIS**

**Joint Action** performed by the **First metatarsophalangeal joint**

1. Abduction
2. Flexion (assists)

**Origin:** 1. Tuberosity (medial process)  
2. Plantar Fascia  
3. Flexor retinaculum

For example the points big toe in (away from other toes)

**Insertion:** First proximal phalanx – Base (medial aspect)

**Common distortions due to weakness** is Hallux valgus or the big toe pointed out towards other toes

## **ADDUCTOR HALLUCIS**

**Joint Action** performed by the **First metatarsophalangeal joint**

1. Adduction
2. Flexion (assists)

For example points big toe out towards other toes

**Origin:** 1. Oblique Head  
2. Second, Third, and fourth metatarsals – Bases  
3. Peroneus longus tendon sheath

**Insertion:** 1. Transverse Head  
2. Third, Fourth and fifth plantar metatarsophalangeal ligaments  
3. Deep transverse metatarsal ligament

**Common distortions caused by tightness** is Hallux valgus or the big toe pointed out towards other toes

## CHAPTER 2

1. Hyperextension
  - A. Moving a body part in an inferior direction
  - B. More extension than normal
  - C. Toward body
  - D. None of the above
  
2. Supination
  - A. Circular movement
  - B. Forward motion, occurs at glenohumeral joint
  - C. Palm turning upward.
  - D. All of the above
  
3. Internal rotation-
  - A. While rotating on its own long axis, the anterior surface moves toward the midline.
  - B. Moving or lifting and body part in a superior direction.
  - C. Pointing foot away from body
  - D. None of the above
  
4. Elevation is moving a body part in superior direction.
  - A. True
  - B. False
  
5. Plantar flexion (ankle) is pointing foot up towards body.
  - A. True
  - B. False
  
6. Depression is moving a body part in an inferior direction.
  - A. True
  - B. False
  
7. Dorsiflexion(ankle) is pointing foot up towards body.
  - A. True
  - B. False
  
8. Plantarflexion is turning feet inward so the soles face each other
  - A. True
  - B. False

The test will ask questions about muscle attachments and function.  
We suggest the practice exams online

<http://winkingskull.com/navigation.aspx>





# CHAPTER 3

# **Skeletal System**

# The Skeletal System

The skeleton is the name given to the collection of bones that holds the rest of our body up. Our skeleton is very important because it provides the framework and support needed to perform the various movements that occur during exercise or sport. This system has four major functions. It protects our vital organs such as the brain, the heart and the lungs. It gives us the shape that we have; without our skeleton, we would be a blob of blood and tissue on the floor. Our skeleton allows us to move because our muscles are attached to our bones, so when our muscles move, the bones move, and we move.

At birth, the skeleton has approximately 350 bones. By adulthood, due to fusions and joining of bones, there will be 206 bones. More than half of your 206 bones are found in your hands and feet. Bone is one of the hardest structures in the human body; it possesses a certain degree of toughness and elasticity. The bone, itself can bend or stretch at very small degrees to allow certain stresses to be placed upon it before reaching the extreme – fracture. Our bones don't simply work alone – they join together to form joints.

A tough, smooth shiny substance called cartilage covers the end of each bone. The cartilage-coated bone-ends are kept apart by a thin film of slippery fluid that works like oil in a car. All of this is so your bones won't scratch and bump against each other when you move. Ligaments, which are strong stretchy bands, hold our bones together. Contractile tissue moves the bones and creates the necessary force and power of the athlete. This adult bone structure can be divided into two systems, the *axial skeleton* (the trunk or center of our body) and the *appendicular skeleton* (our limbs or extremities).

## Skeleton Function

- Holds and protects organs
- Moveable rigid structure
- Red blood cells are manufactured in long bones
- Provides attachment for muscles
- Leverage system

## Bones in the Skeleton

Skeletal bones are divided up into classes: long bones (which make up the limbs); short bones (which are grouped together to strengthen and provide support for our skeleton); flat bones (which protect our body); and irregular bones (odd shaped bones that don't fit the other categories). These can be seen schematically in Figure 1.

**Long Bones** are found in the extremities, and each consists of a body, or diaphysis, which is cylindrical. It has a central cavity and a wall consisting of dense, compact bone. The cavity in the middle of the body, or medullary cavity, contains cancellous bone, which looks like a sponge. It has very porous areas that allow for the blood to pass through and bone marrow to be formed. The ends of the long bone are for articulation and to create surfaces for muscular attachment. They are termed epiphyses, and consist of cancellous or porous tissue surrounded by thin compact

bone. Examples of long bones are: clavicle, humerus, radius, ulna, femur, tibia, fibula, metacarpals, metatarsals, and phalanges.

**Short Bones** are seen where a part of the skeleton is intended for strength and compactness and they are very limited in movement. These bones consist of cancellous tissue, covered by a thin layer of compact substance supported by the periosteum. Short bones include the patellae and seamed bones.

**Flat Bones** are typically used for extensive protection or broad surfaces for muscular attachment. These are very broad, flat plates, like the skull and the scapula. The basic structure of the flat bones is two thin layers of compact tissue with cancellous bone in between them. Examples of flat bones are: occipital, parietal, frontal, nasal, lacrimal, vomer, scapula, os coxae (hip bone), sternum, and ribs.

**Irregular Bones** are named for their strange form, and that is why they cannot be grouped under the preceding categories. They consist of cancellous tissue enclosed within a thin layer of compact bone. The irregular bones are: vertebrae, sacrum, coccyx, temporal, sphenoid, ethmoid, zygomatic, maxilla, mandible, palatine, inferior nasal concha, and hyoid.

**Sesamoid Bones** are usually found in areas where a tendon passes over a joint such as the knee, hand or foot. They increase the tendons mechanical advantage and help to protect the tendon from flattening into the joint.

For the strength and conditioning specialist, the skeletal system provides the framework and support needed to perform the various movements that occur during exercise or sport. This system has four major functions. It protects our vital organs, creates form and shape of our body, creates the appropriate levers and structure to allow contractile tissue to produce movement, and provides the body with new blood cells that are formed in the bone marrow.

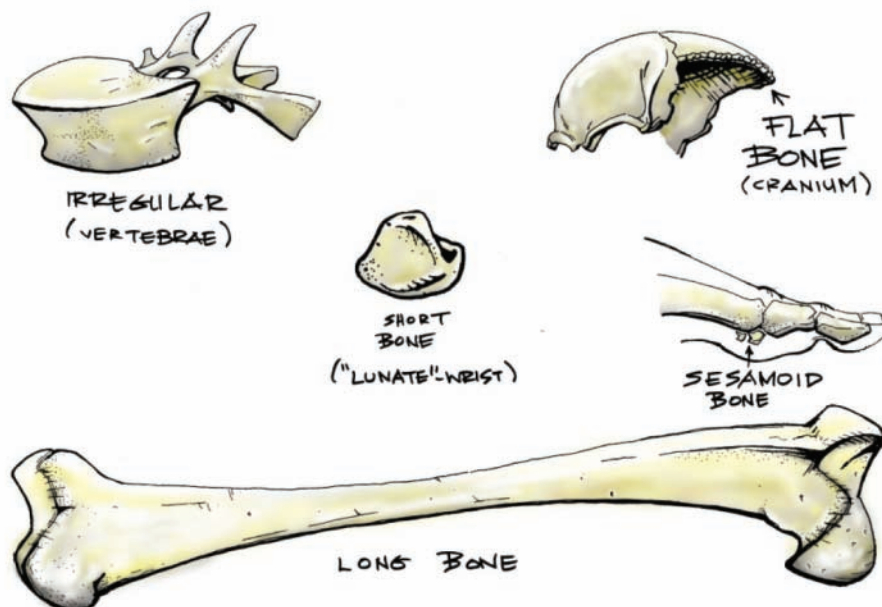


Figure 1. The different types of bones

## How Many Bones in the Skeleton?

### Axial skeleton:

Vertebral column:	26
Skull:	22
Hyoid:	1
Ribs and sternum:	25

### Appendicular skeleton:

Upper extremities:	64
Lower extremities:	62

**Auditory ossicles:** 6

**Total:** 206 bones

## Bones - Brief Overview of Bone Structure

### Upper Extremity

- Shoulder girdle: scapula, clavical
- Arm: humerus
- Forearm: radius (lateral), ulna (medial)
- Wrist: carpals
- Hand: metacarpals, phalanges

### Lower Extremity

- Thigh: femur
- Leg: tibia (medial), fibula (lateral)
- Foot: calcaneus, talus, cuneiforms, tarsals, metatarsals, phalanges

### Axial

- Skull
- Hyoid
- Vertebral column: cervical, thoracic, lumbar, sacrum, coccyx
- Ribs, sternum
- Pelvis: ilium, ischium, pubis

### Spine Structure and Basic Function (Figure 2)

Adult spine has 24 vertebrae plus the sacrum and coccyx

- Cervical 7 vertebrae more extension
- Thoracic 12 vertebrae more flexion
- Lumbar 5 vertebrae more extension

Thoracic spine has a kyphotic curve.

The spine is capable of extension and flexion movements and can also rotate and side bend.

The lumbar and cervical spine has a lordotic curve.

### Hip and Pelvis Structure (Figure 3)



Figure 2 Bones of the spine

Four bones make up the pelvic girdle.

- Sacrum. The interpace between the spine and the pelvis
- Ilium
- Ischium
- Pubis

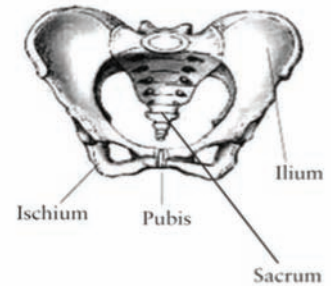


Figure 3 Hip & pelvic girdle

### Shoulder Structure (Figure 4)

- Scapula (shoulder blade)
- Humeral head
- Clavicle



Figure 4. The shoulder joint

### Joints

- Definition: an interaction of bones.
- Definition of “Degrees of Freedom” of a joint: Planes of motion that joints can move along at one time.

### Types of Joints (Figure 5):

- Ball and Socket Joints (shoulder, hip) The 3 degree joints (moves in three planes at one time)
- Hinge Joints (elbow, knee) Concave surface moving along the convex surface, one degree of freedom (move in one plane).
- Gliding Joints (wrist, foot) Bones slide past each other, three degrees of freedom (moves in three planes at one time).

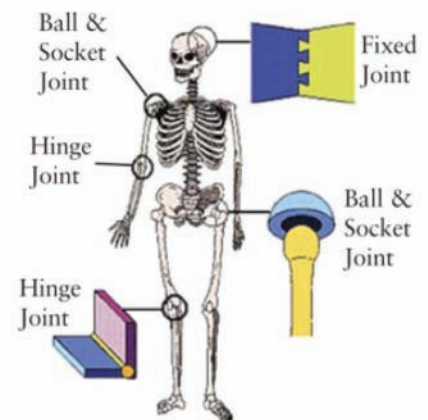


Figure 5. Type of joints and their location in the body

Cartilage covers the end of each bone. The cartilage-coated bone-ends are kept apart by a thin film of slippery fluid that works like oil in a car. A bursa is a fat pad that gives cushion in joints.

**Arthrokinematics:** joint motion

**Synarthroses:** (immovable)

- Cartilaginous joints: cartilage between joint surfaces
- Synchondroses: costal cartilage, growth plates
- Symphyses: secondary cartilaginous joints; intervertebral disk, pubic symphysis
- Fibrous joints: union of bones by fibrous connective tissue
- Sutures: joints between cranial bones
- Gomphoses: between teeth and jaw
- Syndesmosis: interosseous joints such as sacroiliac joints

**Diarthroses:** (synovial joints, moveable joints)

- Plane synovial: uniaxial; translatory motion. Z joints, carpal joints
- Ginglymus: uniaxial; hinge motion. Elbow joint
- Trochoid (pivot): uniaxial; rotation of one bone around a single axis. Proximal radioulnar joint (elbow)
- Bicondylar (condyloid): mostly uniaxial, some rotation; two convex condyles articulating with two concave condyles. Knee joint.
- Ellipsoid: biaxial: two orthogonal axis (flexion/extension in one axis, abduction/adduction in another). Radius, scaphoid and lunate at wrist.
- Sellar (saddle): multiaxial; two saddle-shaped surfaces articulation with each other. Sternoclavicular joint.
- Spheroidal (ball and socket): multiaxial; three degrees of motion. Glenohumeral (shoulder) and femoroacetabular joint (hip)

**Tendon:**

- Connects skeletal muscle to bone
- Type of dense connective tissue: contain collagen fibers in parallel bundles
- Great tensile strength to sustain great forces exerted by muscle belly

**Ligament:**

- Connects bone to bone
- Dense connective tissue
- More elastic fibers than tendons-must stretch more
- Three types: reinforcing (joint capsules); guiding (in movements); restrictive (limit movement)

**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.

**Lumbar Spine:**

*Flexion: 75 degrees*

Bend forward at the waist.

*Extension: 30 degrees*

Bend backward.

*Lateral bending: 35 degrees*

Bend to the side.

**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.

**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.

**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.

**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.

**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.

**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.

## CHAPTER 3

1. Which section in the spine whose basic function is flexion?
  - A. Cervical
  - B. Thoracic
  - C. Lumbar
  - D. Both A&C
2. These bones are intended for strength and are very limited in movement
  - A. Long
  - B. Short
  - C. Flat
  - D. Irregular
3. Which is not correct about Ligaments?
  - A. Dense connective tissue
  - B. Stretch less than tendons
  - C. More elastic fibers than tendons
  - D. None of the above
4. Flexion of the hip typically is
  - A. 45-50 degrees
  - B. 45-90
  - C. 80-90 degrees
  - D. 110-130 degrees
5. Extension of the neck is
  - A. Touch Sternum with Chin
  - B. Pointing up with chin
  - C. Bring ear close to shoulder
  - D. Point chin to shoulder
6. An example of a long bone is
  - A. Femur
  - B. Scapula
  - C. Vertebrae
  - D. Metacarpal

7. Extension of the spine means that you are
- A. Bend forward from the waist
  - B. Bending backwards
  - C. Bend Sideways
  - D. Rotating for the hips
8. What is the total number on bones in an adult human body?
- A. 350
  - B. 206
  - C. 150
  - D. 288
9. Pronation of the Ankle means
- A. Bend to ankle so toes point down
  - B. Bend ankle so toes point up
  - C. Turn foot so the sole faces in
  - D. Turn foot so the sole faces out

# CHAPTER 4

# Nervous System

## Nervous System

The nervous system is a very complex and delicate component of the body. It is the central command center that allows us to gather information about our internal and external environments, process and interpret it, and then respond. The main, and most important, component of the nervous system is the **central nervous system**, which is composed of the **brain, brainstem and spinal cord**. The second component is the **peripheral nervous system**, which is composed of cranial nerves that arise from the brainstem, and the spinal nerves that arise from the spinal cord. The third component is the **autonomic nervous system**, which can be broken down into the **sympathetic** and **parasympathetic nervous systems**. These three major components work together to transmit signals, or messages, controlling all aspects of bodily function.

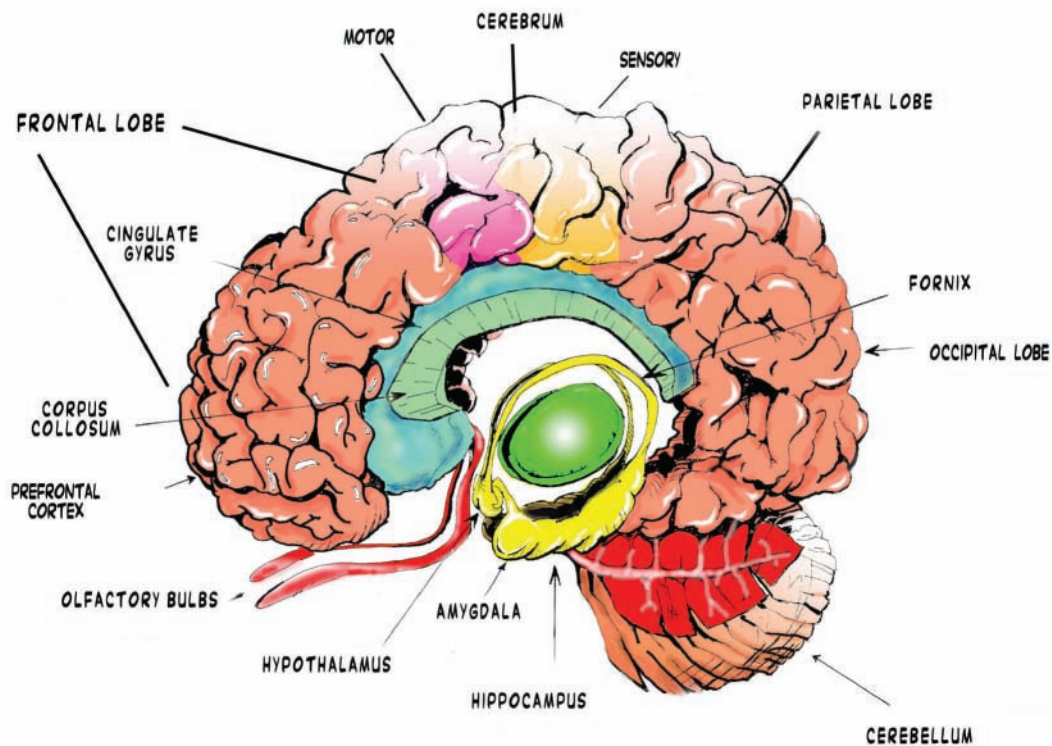
### **The Central Nervous System**

The central nervous system (CNS) represents the largest part of the nervous system, including the brain and the spinal cord. These serve as the main processing center for the whole nervous system, thus controlling all the workings of the body. It is one of two major divisions of the nervous system. Together with the peripheral nervous system (PNS), it has a fundamental role in the control of behavior.

The PNS is outside the brain and spinal cord. It consists of the nerves and neurons that reside or extend outside the CNS – to serve the limbs and organs. Unlike the CNS, however, the PNS is not protected by bone or the blood-brain barrier, leaving it exposed to toxins and mechanical injuries.

### **The Brain**

The brain is the command center of the nervous system. It processes and sends messages throughout the entire nervous system. The brain receives sensory input from the spinal cord, and the spinal and cranial nerves. It then processes these inputs and coordinates appropriate responses and motor outputs. Weighing about three pounds, the brain consists of three main structures: the cerebrum, cerebellum and brainstem. It can be further divided into the lower or mid-brain, and the cerebral cortex. Figure 1 shows a detailed diagram of all the areas of the brain.



## Brainstem

- The link between the sensory and motor nerves coming from the brain to the body and vice versa.
- Connects the brain to the spinal cord.
- In charge of all the functions your body needs to stay alive, such as breathing, digestion and circulation.
- Important component of coordination and control movement, balance and posture stabilization. Necessary when performing a single-leg dumbbell shoulder press with alternating arm motion.

The **Medulla Oblongata** is the lower portion of the brainstem. It is responsible for controlling several major autonomic functions of the body, notably respiration and circulation.

## Basal Ganglia

- Instrumental in the initiation and control of receptive voluntary movements, as well as aiding in postural maintenance and muscle tone. (i.e., walking, running, multiple repetitions during resistance training)
- Monitors specific movement parameters such as velocity, direction and amplitude.

- Comparing actual movement with incoming sensory information to help proper movement. Necessary when performing multi-planar lunges.

## Cerebellum

- Compares and integrates sensory information from the body and the external environment with motor information from the cerebral cortex to ensure smooth coordinated movement.
- Based upon necessary input it receives, it will:
  - Decide the best way to initiate and execute movement.
  - Regulate the muscle force needed with load variations.
  - Activates proper postural muscles to maintain balance during the movement.
- Assist in planning the next movement that should occur.
- Vital for all multi-sensory exercises.

The **Cerebrum** is the control center of the brain. It is divided into two hemispheres (left and right), and each consists of four lobes (frontal, parietal, occipital and temporal). It is the largest and most prominent part of the human brain, and consists of approximately 85% of the weight of the human brain. It is the thinking part of the brain and it controls your **voluntary** muscles – the ones that move when you want them to.

The **Cerebral Cortex** is the outer most portion of the brain. It is also divided into four lobes: frontal, parietal, occipital, and temporal. Many areas of the cerebral cortex process sensory information, or coordinate the motor output necessary for control of movement.

The **Frontal Lobes** are considered our emotional control center and home to our personality. They are involved in motor function, problem solving, spontaneity, memory, language, initiation, judgment, impulse control, and social and sexual behavior. The frontal lobes are extremely vulnerable to injury due to their location at the front of the cranium, proximity to the sphenoid wing and their large size. Studies have shown that the frontal area is the most common region of injury following mild to moderate traumatic brain injury.

The **Parietal Lobe** is positioned above (superior to) the occipital lobe and behind (posterior to) the frontal lobe. It plays important roles in integrating sensory information from various parts of the body, and in the manipulation of objects. Portions of the parietal lobe are involved with visuospatial processing.

The **Occipital Lobes** are the smallest of four true lobes. Located in the rearmost portion of the skull, they are part of the forebrain structure. They are behind (posterior to) the temporal lobes where visual information reaches the cortex.

The **Temporal Lobes** are part of the cerebrum. They lie at the sides of the brain, beneath the lateral or Sylvian fissure. Seen in profile, the human brain looks something like a boxing glove. The temporal lobes are where the thumbs would be. They enclose the hippocampi and amygdalae.

The **Hippocampus** is a part of the brain located inside the temporal lobe (humans and other mammals have two hippocampi, one in each side of the brain). It forms a part of the limbic system and plays a part in memory and spatial navigation. In Alzheimer's disease, the hippocampus becomes one of the first regions of the brain to suffer damage; memory problems and disorientation are amongst the first symptoms. Damage to the hippocampus can also result from oxygen starvation (anoxia) and encephalitis.

The **Limbic System** is not a structure, but a series of nerve pathways incorporating structures deep within the temporal lobes, such as the hippocampus and the amygdale. It is involved in the control and expression of mood and emotion, in the processing and storage of recent memory, and in the control of appetite and emotional responses to food.

The **Olfactory Bulb** is a structure of the vertebrate forebrain involved in olfaction, the perception of odors. Odor information is easily stored in the long term memory and has strong connections to emotional memory. This is possibly due to the olfactory system's close anatomical ties to the limbic system and hippocampus, areas of the brain that have long been known to be involved in emotion and place memory, respectively.

The **Thalamus** and **Hypothalamus** are prominent internal structures. The thalamus has wide-ranging connections with the cortex, and many other parts of the brain, such as the basal ganglia, hypothalamus and brainstem. It is capable of perceiving pain but not at accurately locating it. The hypothalamus has several important functions, including control of the body's appetite, sleep patterns, sexual drive and response to anxiety.

**Anterior Cingulate Cortex (ACC)** is the frontal part of the cingulated cortex. The ACC forms a collar around the corpus callosum, which relays neural signals between the right and left hemispheres. It appears to play a role in a wide variety of autonomic functions, such as regulating heart rate and blood pressure, and is vital to cognitive functions, such as reward anticipation, decision-making, empathy and emotion.

## **The Spinal Cord**

The spinal cord extends from the medulla oblongata in the brain and continues to the conus medullaris near the lumbar level at L1-2, terminating in a fibrous extension known as the filum terminale. The adult spinal cord is approximately 18 inches long, ovoid-shaped, and is enlarged in the cervical and lumbar regions.

The spinal cord conducts sensory information from the PNS to the brain using ascending pathways called afferent pathways. Using descending pathways called efferent pathways, the brain sends information through the spinal cord to the specific areas that need be affected. These efferent pathways typically carry motor information from the brain to our various target sites. The target sites are skeletal muscles, smooth muscles, cardiac muscles, and glands.



The spinal cord is divided into 31 different segments, with motor nerve roots exiting in the ventral aspects, and sensory nerve roots entering in the dorsal aspects. The ventral and dorsal roots later join to form paired spinal nerves, one on each side of the spinal cord.

There are 31 spinal cord segments:

- 8 cervical segments
- 12 thoracic segments
- 5 lumbar segments
- 5 sacral segments
- 1 coccygeal segment

### **The Peripheral Nervous System (PNS)**

The PNS consists of 12 cranial nerves, and 31 pairs of spinal nerves and sensory receptors. These peripheral nerves serve two main functions:

- They provide a connection for the nervous system to activate different bodily organs, such as muscles. Efferent (motor) information going to an effector site.
- They relay information from the bodily organs back to the brain, providing a constant update of the relation between the body and the environment. This is afferent (sensory) information.

The peripheral nerves of the **efferent** division are divided into two main divisions:

- The **Somatic Nervous System** connects to the skeletal muscles of the body, and provides the means for nervous system to initiate and produce movement.
- The **Autonomic Nervous System** (ANS) affects all of the other tissues and organs that are not skeletal muscle. It is a self-regulatory system that allows people to involuntarily adapt to the environment. It adjusts or modifies some functions in response to stress; both physical and mental. It helps regulate:
  - Blood vessel diameter and blood pressure.
  - The heart's electrical conductivity and ability to contract.
  - Respiratory function, such as the bronchium diameter with respiration
  - Functions of the stomach, intestine, salivary glands, hormone secretion, urinary and sexual functions.

The ANS reaches homeostasis due to its two components: the **Sympathetic** and **Parasympathetic Nervous System**.

The **Sympathetic Nervous System** (SNS) is sometimes referred to as the “Fight or Flight” system because it is activated in highly stressful situations, such as danger. It allows for increased responses of the body under conditions of physical or psychological stress.

**Examples:**

1. During intense exercise the body's temperature is increased, and this initiates several automatic responses. Heat or thermal receptors convey stimuli to the sympathetic control centers of the brain. An inhibitory message is then sent along the sympathetic chain of nerves to the blood vessels of the skin, causing a dilatation of the cutaneous blood vessels. This now greatly increases the flow of blood to the surface of the body, where heat is lost by radiation and evaporation from sweating. This is the body's cooling mechanism.
2. The SNS responds to environmental heat in another important way. The rise in body temperature is sensed by the hypothalamic center. Stimuli are then sent, via sympathetic nerves to the sweat glands, resulting in appropriate sweating. This serves to cool the body by the loss of heat resulting from evaporation of the sweat aided by a cool breeze. We cannot voluntarily influence the dilatation of our blood vessels or the adequacy of our sweating in response to heat in other ways.
3. Control of the rate and strength of cardiac contractions is also under the predominant control of the SNS. During intense exercise, there is a greater cardiac demand for blood and oxygen, so as the intensity of the exercise increases, the SNS sends transmissions to the heart to increase cardiac output by increasing the intensity and frequency of the heart rate.

**The Parasympathetic Nervous System** is sometimes referred to as the "Wine or Dine" pathway, meaning that it is a very slow, relaxing and moderated process when stimulated. It calms the body back down and returns it to a normal state of operation.

**Examples:**

1. When a stimulus is applied to an organ, such as a bright light flashed into the eyes, a message is conducted through sensory fibers to the midbrain. This creates a stimulus that travels through the parasympathetic fibers of the oculomotor (third cranial) nerves to the pupils, causing automatic contraction of the pupillary muscles to constrict the pupil. This reduces the amount of light reaching the sensory cells in the retina on the back of the eyeball.
2. Food enters into the stomach, creating a stimulus that is conveyed by afferent fibers of the vagus nerve to a specific nucleus of the vagus nerve in the brain. Here, messages are interpreted and then transported through efferent fibers of the vagus, back to the stomach. These stimulate the secretion of gastric juices and contraction of the stomach muscles to mix the food with the secreted digestive juices, and slowly move the digested food contents into the intestines.

The peripheral nerves of the **afferent** division contain sensory receptors. The sensory receptors are specialized structures located through the body that are designed to transform environmental stimuli (heat, light, sound, taste, motion, etc.) into sensory information that the brain and/or spinal cord can then interpret to produce a response.

- **Mechanoreceptors** respond to mechanical forces (touch and pressure). They are located in muscles, tendons, ligaments, and joint capsules. They include muscle spindles, Golgi tendon organs and joint receptors.
- **Nociceptors** respond to pain (pain receptors).
- **Chemoreceptors** respond to chemical interaction (smell and taste).
- **Photoreceptors** respond to light (vision).

**Muscle spindles** are major sensory organs of the muscle.

- They are sensitive to change in length and rate of length of change.
- When a muscle is stretched, its spindles are also stretched.
- This information is transmitted to the brain and the spinal cord to update the nervous system on the status of the muscle length, and the rate at which that muscle is lengthening.
- When excited, the muscle spindle will cause the muscle to contract – this prevents the muscle from stretching too far, and/or too fast to prevent injury.

**Golgi tendon organs** are located within the musculotendinous junction.

- They are sensitive to changes in muscular tension and the rate of the tension change.
- When excited, the Golgi tendon organ will cause the muscle to relax, preventing it from being placed under excessive stress, and thus resulting in injury. Prolonged Golgi tendon organ stimulation provides an inhibitory action to muscle spindles – this neuromuscular phenomenon is called **autogenic inhibition** (the contracting muscle is inhibited by its own receptors).

**Joint receptors** are located in, and around the joint capsule. They:

- Respond to pressure, acceleration, and deceleration of the joint.
- Signal extreme joint positions and thus help to prevent injury.
- Initiate a reflexive inhibitory response in the surrounding muscles if there is too much stress placed on the joint.

## **Anatomy and Function of a Neuron**

A **neuron**, or nerve cell, is the basic unit of the nervous system, and is how synapses or messages are sent to various parts of the body. The nervous system is similar to an electric circuit, in which the circuitry is all connected and relays messages back and forth aiding in sensory and motor functions. Neurons are highly specialized cells, and are capable of responding to stimuli, and conducting these stimuli from one part of the cell to another. They have a very high requirement of oxygen; they can't live without it for more than a few minutes. When we are born, there are only a certain number of neurons that we have. They do not reproduce like most other cells, but some can regenerate or repair specific parts if the cell body remains intact.

There are three main functional classifications of neurons that are determined by the direction of their nerve impulses.

- **Sensory** (afferent) – transmit afferent nerve impulses from receptors to the brain and/or spinal cord.
- **Motor** (efferent) – transmit efferent nerve impulses from the brain and/or spinal cord to effector sites such as muscles or glands.
- **Interneurons** (Inter) – transmit nerve impulses from one neuron to another.

### **The basic anatomy of the neuron:**

**Axon** – is a cylindrical projection from the cell body that transmits nervous impulses to other neurons or effector sites (muscles, organs, other neurons, etc.). This is the part of the neuron that provides communication from the brain and/or spinal cord to other parts of the body.

**Axon Terminals** – a specialized hair like structure at the end of the axon that is used to release neurotransmitter chemicals and communicate with target neurons, allowing conductivity into the area.

**Cell Body** – the cell body of the neuron; it contains the nucleus (also called the soma), and other organelles such as lysosomes, mitochondria and Golgi complex.

**Dendrites** – the branching structure of a neuron that receives messages (attached to the cell body). It is responsible for gathering information from other structures back into the neuron.

**Myelin Sheath** – the fatty substance that surrounds and protects some axons; also provides for higher conduction velocity

**Node of Ranvier** – one of the many gaps in the myelin sheath – this is where the action potential (chemical mediation of a nerve impulse) occurs.

**Nucleus** – the organelle in the cell body of the neuron that contains the genetic material of the cell.

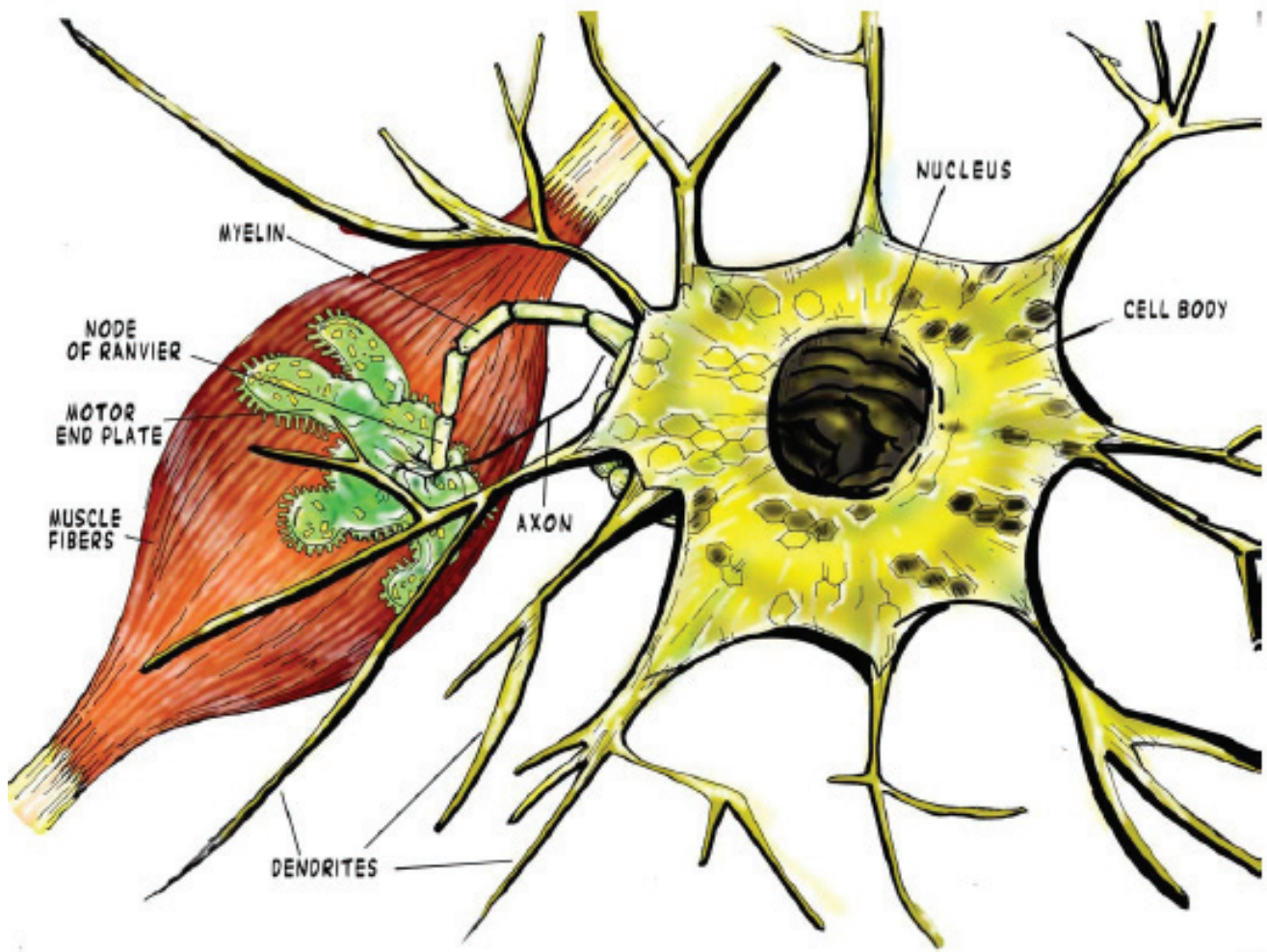
**Schwann Cells** – are a variety of neuroglia that mainly provides myelin insulation to axons in the PNS of jawed vertebrates. The vertebrate nervous system relies on this myelin sheath for insulation, and as a method of decreasing membrane capacitance in the axon.

**Gap Junction** – where the synapse jumps from schwann cell to schwann cell over the gap junction by conduction of the myelin sheath.

**Acetylcholine** (ACh) – neurotransmitter extensively found in the brain and autonomic nervous system. It stimulates the muscle fibers to go through a series of steps that produce muscle contractions.

**Ganglion** – cluster of cell bodies of neurons. Examples are the dorsal root ganglion of peripheral sensory nerves and the sympathetic chain ganglion.

Nerve impulses are received by the dendrites and carried along the axon to the next synapse. Here, neurotransmitters are released to travel across the synapse and stimulate the next dendrite or the target tissue. If the stimulus is great enough, the process will continue.



## CHAPTER 4

1. The peripheral nervous system serves the limbs and organs of the body.
  - A. True
  - B. False
2. The thinking part of the brain that controls voluntary muscle movement is the cerebrum.
  - A. True
  - B. False
3. The limbic system of nerve pathways is involved in control and expression of mood and emotion and therefore in the control of appetite and emotional responses to food.
  - A. True
  - B. False
4. The spinal cord conducts information both to and from the brain.
  - A. True
  - B. False
5. The brain stem\_\_\_\_
  - A. Links the brain to sensory and motor nerves.
  - B. Is essential for the function of digestion
  - C. Is in charge of breathing and circulation
  - D. All of the above
6. Acetylcholine is a neurotransmitter that stimulates muscle contraction and is also found extensively in the brain.
  - A. True
  - B. False
7. Sensory information is carried to the brain to various skeletal muscle sites.
  - A. True
  - B. False
8. The autonomic nervous system helps regulate all of the following except?
  - A. Blood vessel diameter
  - B. Blood vessel pressure
  - C. Peristaltic movement in digestion
  - D. Hearts electrical conductivity and ability to contract

9. What is the basic unit of the nervous system and is how synapses or messages are sent to various parts of the body?
- A. Nucleus
  - B. Neuron
  - C. Soma
  - D. Dendrites
10. The branching structure of a neuron that receives messages is a
- A. Dendrite
  - B. Ganglion
  - C. Axon
  - D. Synaptic cleft
11. Voluntary movement is most associated with which of the following?
- A. Parietal lobe
  - B. Occipital
  - C. Temporal lobe
  - D. Frontal lobe
12. The structure of the brain involved the perception of odors is the?
- A. Limbic system
  - B. Thalamus
  - C. Olfactory bulb
  - D. Hypothalamus
13. What part of the brain controls autonomic functions of the body.
- A. Cerebellum
  - B. Cerebrum
  - C. Medulla Oblongata
  - D. Fornix
14. What system is a series of nerve pathways incorporating structures deep within the temporal lobes, involved in the control and expression of mood and emotion, in the processing and storage of recent memory, and in the control of appetite and emotional responses to food?
- A. Limbic system
  - B. Somatic nervous system
  - C. Autonomic nervous system
  - D. Sympathetic system

15. What is sometimes referred to as the “wine or dine” , pathway meaning that it is a very slow, relaxing and moderated process when stimulated.
- A. Parasympathetic nervous system
  - B. Sympathetic nervous system
  - C. Somatic nervous system
  - D. Nomatic nervous system
16. Preganglionic fibers are?
- A. Fibers from the Central nervous system to the ganglion.
  - B. In the Sympathetic division.
  - C. In the Parasympathetic division.
  - D. All of the above
17. Neurotransmitters are actually tiny sacs of chemicals.
- A. True
  - B. False





# CHAPTER 5

## Principles of Movement

# Principles of Movement

## Biomechanics of the Locomotor System

### Planes of Motion

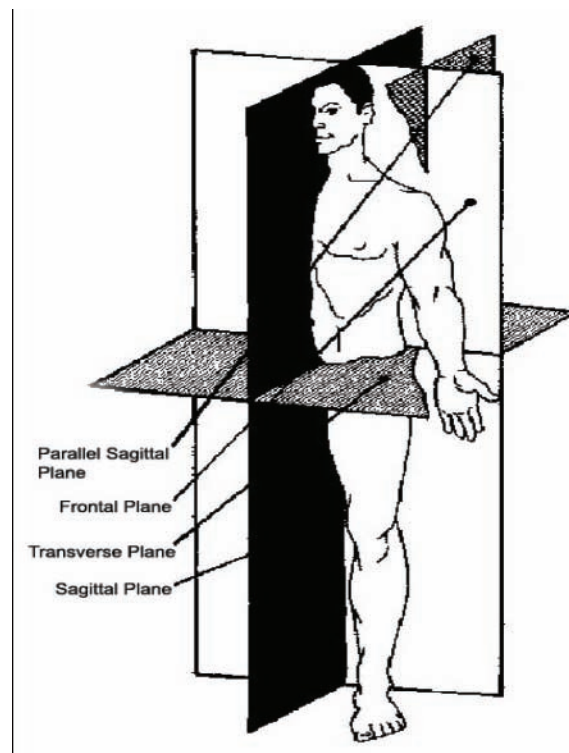


Figure 1. The planes of motion in the body

**Parallel Sagittal Plane** (Parallel Sagittal) - parallel with midline, divides body laterally.

**Frontal Plane** (Coronal) - divides the body into front and back (lateral raise, pull down, military press).

**Transverse Plane** (Horizontal Plane) - divides the body superiorly and inferiorly (rotation at the waist, bench press, internal external rotation).

**Sagittal Plane** - along the side of the body (front pulling down a shade, elbow bending forward, close grip bench, squat).

## Biomechanical Movement

- **Flexion** - bending of a joint that decreases the angle.
- **Extension** - straightening of a joint that increases the angle.
- **Hypoextension** - less extension than normal.
- **Hyperextension** - extension beyond normal limits.
- **Abduction** - away from the body.
- **Adduction** - toward the body.
- **Pronation** - palm turning down.
- **Supination** - palm turning up.
- **Rotation** - around an axis.
- **Circumduction** - circular movement.
- **Protraction** - forward motion, occurs at glenohumeral joint.
- **Retraction** - backward motion, occurs in the glenohumeral joint.
- **Internal rotation** - while rotating on its own long axis, the anterior surface moves toward the midline.
- **External rotation** - while rotating on its own long axis, the anterior surface moves away from the midline.
- **Elevation** - moving or lifting and body part in a superior direction.
- **Depression** - moving a body part in an inferior direction.
- **Dorsiflexion** - (ankle) pointing foot up towards body.
- **Plantarflexion** - (ankle) pointing foot down.
- **Inversion** - turning feet inward so the soles face each other.
- **Eversion** - turning the soles outward.
- **Gliding** - movement of non-angular joints over each other
- **Deviation** - departure from the midline

## Types of Motions Joints and their Movements

- **Neck** - flexion/extension, lateral flexion, rotation
- **Acromioclavicular** - elevation, depression
- **Glenohumeral** - extension, abduction, adduction, rotation - internal and external
- **Scapula** - protraction/retraction
- **Elbow** - flexion/extension, pronation/supination
- **Wrist** - flexion/extension, radial and ulnar deviation
- **Fingers** - flexion/extension, abduction/adduction.
- **Hip** - flexion/extension, abduction/adduction, rotation - internal and external
- **Knee** - flexion/extension
- **Ankle** - plantarflexion/dorsiflexion, inversion/eversion
- **Toes** - flexion/extension

Movement occurs within the human locomotor system through strength, force, and power created by the musculoskeletal system. The contractile tissue, non-contractile tissue, joints, and skeleton are used to create levers to maximize and produce strength, force, and power that are more efficient for motion or work.

Understanding the biomechanics of the musculoskeletal system requires knowledge of the anatomy and planes of movement, as well as the force and lever systems the human body produces and uses to its advantage. The skeletal system provides the framework and support needed to perform the various movements occurring during exercise or sport. Contractile tissue moves the bones and creates the necessary force and power of the athlete. The skeleton is a lever system controlled by the muscles.

## Laws of Motion

### 1) Newton's First Law of Motion: "Law of Inertia"

"Every object in a state of uniform motion tends to remain in a state of motion unless acted upon by an external force applied to it."

There are two types of inertia:

1. **Static**: the mass you are working against doesn't want to move.  
An example would be lifting a weight.

2. **Dynamic:** an object wants to stay in motion unless acted upon by another force. Dynamic inertia can be motive or resistive.

- **Motive:** assists when moving an object (momentum).
- **Resistive:** forces working against motion.

**Constraint:** limiting factor and there are two main types:

**Environmental constraints**

- Spacial
- Temporal

**Biomechanical constraints**

- Leverage
- Friction
- Gravity
- Morphology
- Time lags (time it takes for a signal to travel from the sensory nerve to the brain and back to the motor nerve).
- Zooms

**2) Newton's Second Law of Motion**

The relationship between an object's mass (m), its acceleration (a), and the applied force (F) is simplified in the formula  **$F = ma$** . This law states that the direction of the force vector is in the same direction of the mass's acceleration vector.

$$F = ma$$

**3) Newton's Third Law of Motion**

For every action there is an equal and opposite reaction.

**4) Center of Gravity**

This is depicted as the balance point, or the specific area on which the surrounding forces are equal to zero. It is seen as the concentration of mass. Although, the center of gravity changes through all motions seen in the human body, it is typically around the umbilicus, and moves toward the displaced limb. The closer the center of gravity is to your base of support, the more stability. Posture attempts to balance the forces in the body so their sum equals zero.

**Law of falling bodies:**

The rate that gravity pulls one to the ground. Objects accelerate to the ground regardless of weight, as long as air is not a factor. The rate of acceleration due to gravity is 32 ft/sec<sup>2</sup> or 9.8 m/sec<sup>2</sup>.

## 5) Base of Support

This is where your body comes into contact with the supporting surface. For example, when standing the base of support is the total area around, and in between your feet. Sitting in a chair, the base of support is the area between your feet and your buttocks.

## 6) Balance

The act of keeping your center of gravity over your base of support.

## 7) Stability

Ability to keep the center of gravity over the base of support. The closer the center of gravity is to the base of support, the more stability one will have. An example would be the biceps curl, when the load moves forward and the body moves back in order to find the center of gravity.

## 8) Equilibrium

This is the act of keeping your center of gravity near your base of support and restraining from moving beyond your center of support.

## 9) Force

A force is a push or a pull on a given point, of given magnitude, in a given direction. Force either produces or prevents motion, and a visible change in motion need not occur when a force is applied. This means that a force can be applied to an immovable object. The magnitude of muscular forces can be described in terms of "strength," and can be measured using dynamometers, tensiometers, and strain gauges. A rough estimate of muscular force is 85 to 186 lb/in<sup>2</sup>. When muscles contract, the point of application is found at the attachments of the muscles, and the direction of the muscular force usually runs from the insertion of a muscle toward its origin. In terms of center of gravity, a reaction force acts on the center of gravity. An example would be cable crossovers; leaning forward to stabilize to prevent being pulled back

Any quantity, such as a force, which has a point of application, a magnitude, and a direction, is called a **vector** quantity. This can be depicted as a muscle's insertion (point of application), and the muscle's origin (typically the where the direction of pull is applied to), and the muscular contraction itself (force being applied by the muscle).

- **Vector:** has point of application, magnitude and direction.
- **Resultant:** put two vectors together. To measure take the bottom vector and move it to the top then draw line to original point.
- **Displacement:** change in position.

- Different forms of displacement
  - Straight line
  - Curving line
  - Flying loop (still defined on linear motion)

## 10) Strength

Basic strength is the ability to produce force. **Absolute muscle strength** is the maximal force that a muscle can produce.

## 11) Power

The rate at which work is performed.

$$P = W/T$$

Where **P** is power, **W** is weight of the object and **T** is time. Power movements are considered explosive in nature because the movement is to be performed at an increased rate.

## 12) Velocity

Velocity (**V**) can be defined as the distance (**D**) an object has covered over the time (**T**) the object has been displaced.

$$V = D/T$$

## 13) Linear Motion

Linear motion is when an object and all of its parts move in the same direction at the same time. To increase linear velocity you increase the length per unit of time.

## 14) Angular Motion

Angular motion is circular motion around the fixed axis. The radian is the ratio of the angular distance moved to the length of the radius.

## 15) Angular Velocity

The angular velocity of an object is the angle through which an object rotates during the motion that is occurring. The unit that is used for angular velocity is the radian, and can be defined as: **1 radian = 180°/π or 57.3°**



To increase angular velocity, the radius is shortened. There are two forces generated in angular motion.

Radial force generated along lever.

1. **Centrifugal**: force pushing out along the radius, away from the axis of rotation.
2. **Centripetal**: force pushing in along the radius, towards the axis of rotation.

## 16) Translating Motion

Translating motion is when angular motion combines to create linear motion. An example of this would be the bench press, in which there is angular motion around the shoulder (glenohumeral) joint, but linear motion of the held weights.

## 17) Acceleration

Acceleration is the change in velocity or direction per unit of time.

## 18) Work

Work (**W**) can be defined as the accumulated product of the force (**F**) created and exerted on an object and the distance (**D**) the object is displaced in the direction it has been moved.

$$W = F \times D$$

## 19) Tangential Force

A tangential force is perpendicular, or at a 90° angle, to the radius.

# Machines of the Human Body

## *Levers of the Musculoskeletal System*

A machine is any device which transfers a force from one point to another. According to the Principle of Conservation of Energy, a machine can produce either an increase in force with a corresponding decrease in motion, or an increase in motion with a corresponding decrease in force. There are only two basic types of machines: **levers**, and **inclined planes**. In relation to the human body, we will be talking about a system of levers that are used to transfer force from one point to another. A lever is considered a rigid or semi-rigid body that, when subjected to a force whose line of action does not pass through its pivot point, exerts a force on any object impeding its tendency to rotate. Understanding the terminology of levers is important, so here are some definitions which will be used in this discussion:

- 1.) **Mechanical Advantage** - the relationship or ratio of the moment arm to which force applied (effort) acts to that through which a resistive force (resistance) acts. This means that the muscular effort must be greater than the resistive force to create motion. If the effort (muscle contraction) is greater than the resistance (work needed to be done) then there will be motion applied.
  - A.) **Ideal Mechanical Advantage (IMA)** - represents the theoretical magnification of force if no energy is lost in the form of heat due to friction.
  - B.) **Actual Mechanical Advantage (AMA)** - represents the actual magnification of useful force after friction losses.
- 2.) **Fulcrum** - a lever's pivot point, or axis of rotation.
- 3.) **Moment Arm (M)**- the perpendicular distance from the force to the fulcrum, can be depicted as either the effort moment arm or the resistance moment arm.
- 4.) **Torque** - magnitude of force times the length of the moment arm, or the force applied around an axis of rotation.
 
$$M \times RA = \text{total torque}$$
- 5.) **Muscular effort** - the muscular force created by the musculoskeletal system that creates contraction of the tissue
- 6.) **Resistive Force** - the work being applied to the lever; the outside source that acts opposite to muscular contraction. As you move closer to the line of gravity, the resistance will get smaller.
- 7.) **Resistance area** - the distance from the line of gravity to the load.
- 8.) **Force arm(FA)** - the distance from the center of the joint to the muscle insertion.
- 9.) **Resistance arm(RA)** – distance between fulcrum and point of resistance.

### Class I levers

The first class of lever is depicted by the effort and resistance or load on opposite sides of the fulcrum as shown in Figure 2. An example of this in the human body is the triceps brachii during a triceps push-down.

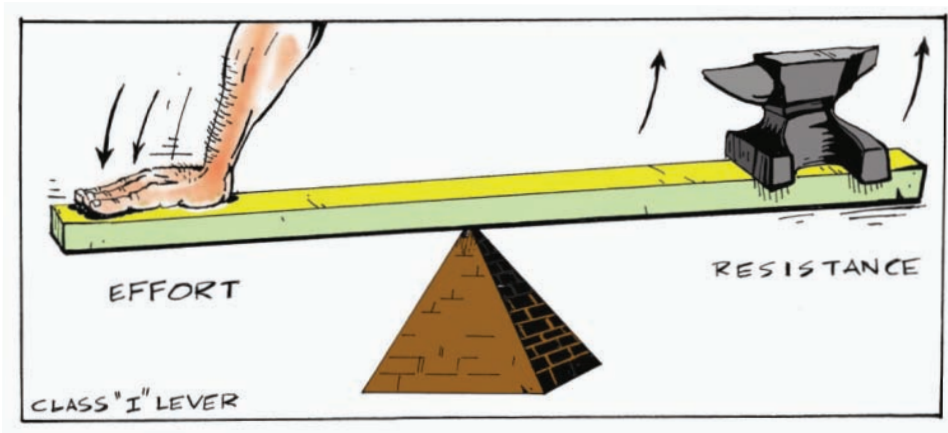
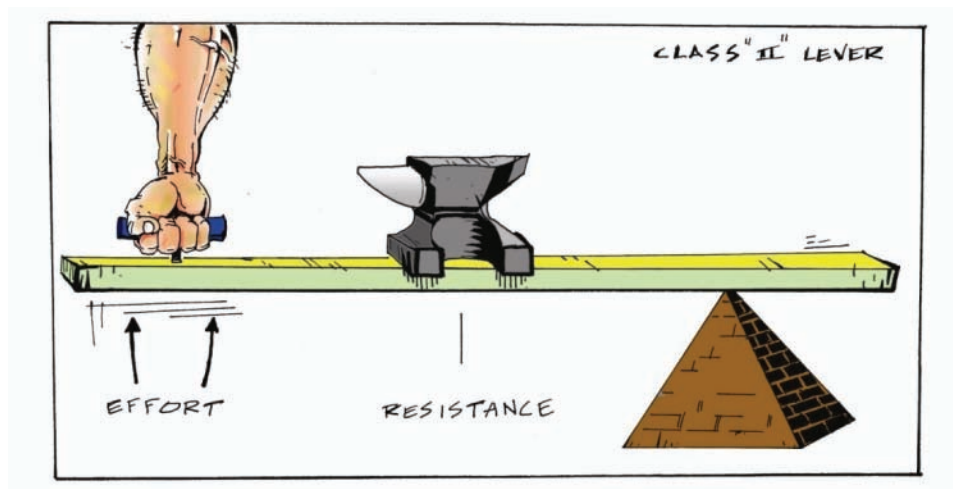


Figure 2. Example of a Class I lever

### Class II levers

A second class lever is classified when the effort and resistance/load act on the same side of the fulcrum, with the muscle contracting through a moment arm longer than that of the resistance moment arm, as shown in Figure 3. In other words, the resistance/load is between the axis of rotation and the force or effort. The effort needed to move the lever is much less from the muscle contraction because the moment arm is longer, and the load is much easier to lift. This lever is the most efficient machine in the human body, but there are minimal areas where it is used. An example of this is the triceps and gastroc-soleus complex. This occurs when the

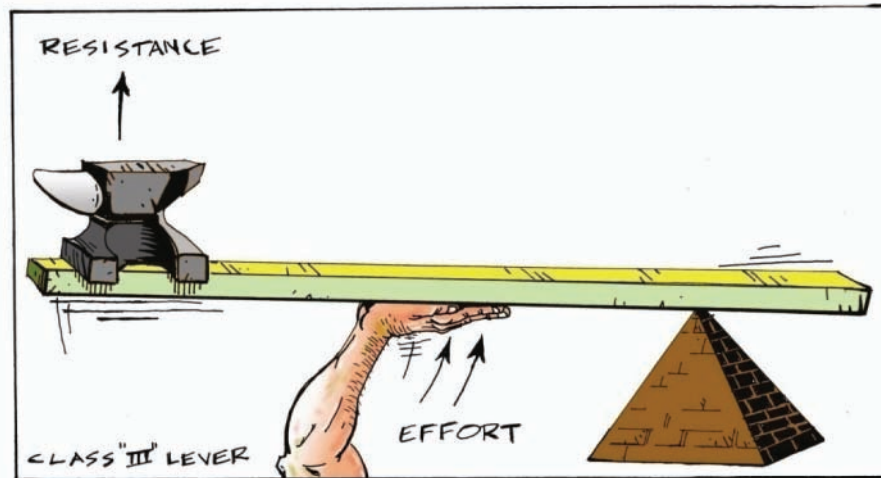


forefoot is on the ground and the heel is being lifted.

Figure 3. An example of a Class II lever

### Class III levers

A third class lever is classified when the effort and resistance act on the same side of the fulcrum, but the moment arm of the muscular force is much smaller than that of the resistance moment arm, as shown in Figure 4. In this classification, a much greater force is needed by the



muscular contraction to move the resistant force. A good example of this is the biceps brachii.  
Figure 4. Example of a Class III lever

The class III lever system is the most common used in the human body. It places the most strain on the musculoskeletal system. It is clear that the human body is at a mechanical disadvantage most of the time with this system.

## The Phase of Locomotion

### The Gait Cycle

The gait cycle is typically broken down into two phases: the *swing* and the *stance phase*.

- **Swing Phase:** The swing phase is repositioning of the non-weight bearing limb resulting in passive flexion of the hip, with some small bursts of muscular effort to start the limb swinging, and then to stop the limb from swinging and to prepare for weight bearing.
- **Stance Phase:** Body weight is supported by the limb, the center of gravity passes through the foot from back to front, and ends with a propulsive thrust. Stance phase is commonly broken down into three separate components.
  - 1) **Stance Phase - "Heel Strike":** The heel strikes the surface and the limb (with a slightly bent knee), acts as a shock absorber. The forward momentum of

locomotion carries the center of gravity through the heel toward the forefoot.

- 2) **Stance Phase** - "Full Flat": The single limb is now fully supporting the weight of the body, and forward momentum is still largely responsible for carrying the center of gravity forward. Around the hip joint, muscular stabilization must occur.
- 3) **Stance Phase** - "Toe Off": Forceful contraction by the plantar flexor musculature pushes the foot against the surface, providing the thrust off from the surface.

## CHAPTER 5

- Turning the feet inward so the soles face each other is an example of
  - Eversion
  - Inversion
  - Plantarflexion
  - Dorsiflexion
- The wrist is more proximal to the shoulder than the elbow
  - True
  - False
- The Rhomboids are more medial than the deltoids
  - True
  - False
- The hips are inferior to the Ribcage
  - True
  - False
- When heels are down and toes are lifted pointing up the ankle is in
  - Sagittal
  - Transverse
  - Dorsiflexion
  - None of the above
- Match the biomechanical movement w/the exercise.

<u>A</u> Flexion	_____	Calf Raises
<u>B</u> Extension	_____	Chest press
<u>C</u> Protraction	_____	Tricep Pressdown
<u>D</u> Retraction	_____	Serratus Pushup
<u>E</u> Plantar Flexion	_____	Side lying leg raise
<u>F</u> Abduction		
<u>G</u> Horizontal Adduction		
- Gravity is the resistance encountered in most free wt. exercises
  - True
  - False

8. An object that is not moving would be in static inertia
- A. True
  - B. False
9. The effort required to move a class II lever is much less than with a class III
- A. True
  - B. False

# CHAPTER 6

# Motor Learning



**Motor learning:** the process by which someone learns to develop skillful movement.

**Cerebral Cortex:** Part of the brain where learning occurs. The cortex is divided into a motor and sensory region. The motor region is further broken up into the supplemental motor area, premotor area and the primary motor cortex. The sensory region is divided into the somatic area and the somatic association area.

**Motor Cortex:** The **primary motor cortex** contains representations of every muscle group in the body. Some muscle groups of certain regions have more representation than others. For example, areas involved in fine movement, such as the hands and mouth, are largely represented and, therefore, provide more control is provided.

The **premotor area** controls the movement patterns of muscle groups to perform specific tasks. An example of this would be stabilization and positioning of proximal extremities so that distal extremities can perform a task.

The **supplemental motor area** seems to control “head and eye movements, attitudinal movements, vocalization and yawning” 1. Little is known about the supplemental motor area. It seems to set a background for movement of the hands and feet.

**Sensory Cortex:** The somatosensory cortex lies posterior to the central sulcus and the motor cortex. It is divided into two main areas, referred to as Somatic Sensory Area I and Somatic Sensory Area II. Area I seems to play a significantly larger role in sensory function than Area II. Area I contains regions that correlate directly with specific body parts and receive sensory input from these areas. This is referred to as the homunculus. Some parts of the body have larger areas of representation, such as the lips and thumbs, based on the amount of sensory receptors found in those regions.

The input and output of the cerebral cortex has a somatotopic (body map) organization in which the cortical neurons influencing muscles, and the sensory information from the various parts of the body, are arranged in an orderly sequence.

**Cerebellum:** Area of the brain where fine-tuning of movement occurs. It does not cause muscles to contract, but processes information of body position and external forces exerted on the body, along with motor activities elicited by other areas of the brain<sup>1</sup>. The cerebellum assists in coordinating movement patterns of the distal extremities, and also in coordinating the timing and sequence of movement patterns.

The cerebellum has two hemispheres and a middle region called the vermis. It has three functional divisions, each of which receives input and sends output to distinct parts of the central nervous system.

The divisions are:

**Spinocerebellum:** processes information regarding limb and joint position.

**Cerebrocerebellum:** involved in motor control, such as fine finger movements in typing.

**Vestibulocerebellum:** involved in balance and eye movement function.

**Dorsal Columns:** area of the spinal cord which carries proprioceptive input to the brain.

**Proprioception:** sensation of knowing a body part's position in space. For example, if one's eyes are closed, and the shoulder is abducted to 90 degrees, proprioception will allow the person to know that the shoulder is abducted without seeing it. This system does not rely on visual cues to determine the body's position. It is solely based on the feedback of the mechanoreceptors.

**Mechanoreceptors:** sensory cells that respond to pressure and distortion, and send positional feedback to the brain along the dorsal columns.

**Muscle spindles:** proprioceptive receptors that provide feedback on muscles when they are stretched or relaxed. This information is used in interpreting position and movement of a joint based on the amount of stretch in the muscle. They measure muscle length and the speed of any changes.

**Golgi Tendon Organs:** receptors that provide feedback on the amount of tension being exerted on a tendon. It will cause the muscle to contract to avoid being over stretched.

**Afferent pathway:** ascending pathway along which all sensory information is carried to the spinal cord and brain.

**Corticospinal tract:** this is the major pathway of nerves linking the muscles to the brain. Along this pathway, signals are transmitted from the brain to the muscles in order to create movement.

**Efferent pathway:** descending pathway along which motor information is carried from the brain and spinal cord to the target tissues.

**Cognitive** (understanding): "thinking processes of the brain, utilizing both the sensory input to the brain as well as information already stored in memory" 1. The sensory input and stored memories are linked in the association areas of the cerebral cortex. Here they are integrated with motor information in order to develop necessary patterns.

- Perception
- Throughput (taking something in putting out)
- Info processing
- Memory
- Knowledge of performance/ knowledge of results

### **Phases of learning**

1. Cognitive/ conscious awareness (learning what to do): this is the discovery stage, where one learns how to actually produce motion in a particular region of the body correctly. It requires conscious effort and concentration.

There will be errors in this stage as the motion pattern has not yet been engrained. This stage is dependent on feedback, movement sequence, performance, and instruction during repetition and practice.

There is a significant sensory component to this phase as it involves interpretation of sensory information.

2. Associative phase (develop plan of action): this is the stage where more complex and challenging movements will be added once one is comfortable moving in their functional range with kinesthetic awareness. This might include the requirement of muscle activation in order to stabilize the region to perform the motion.

Errors are reduced as fundamentals of the movement are established. Less conscious effort is required. Focus shifts to “consistency of performance, success and refinement”. Many repetitions are required to reduce the need of conscious effort.

3. Automatic phase (automatic): this occurs when the motion is embedded and does not have to be consciously thought of in order to perform. This will be demonstrated when motions can be performed on unstable surfaces, or when there are external challenges trying to alter the movement pattern.

## Trends

### Ordered sequence:

- Progression variables:
- Unloaded to loaded
- Simple to complex (uniplanar to triplanar or isometric to concentric to eccentric)
- Slow to fast
- Endurance to strength to power
- Increased resistance
- Stable to labile (decreased points of support or use of unstable surfaces like ball or board) 2,

General to specific: movements that are gross and large, and then they become defined and controlled (jerky to smooth)

Uncontrolled → controlled repeatable mobility

Stability → dynamic locomotion

**Reflex:** automatic involuntary motor response to an afferent signal.

**Reactive:** action based on a cue or set order.

**Contextual interference:** being able to do any task at any time.

**Proactive:** anticipating and carrying out what needs to be done in an array of environmental changes.

## **Beginner's problems**

### **Information Overload**

1. do not know where to focus
2. takes too long to process information
3. poor decision making
4. poor movement patterns

Skilled performers eliminate unnecessary information.

### **Trainer function**

1. identify the goal
2. identify the environment
3. structure specific program according to goals
4. provide motivation and maintain focus
5. provide feedback

## CHAPTER 6

1. Match the activity with its most prevalent sensory receptors
  - A. Mechanoreceptors     \_\_\_ picking up a can of beer
  - B. Nociceptors         \_\_\_ cars headlights
  - C. Chemoreceptors     \_\_\_ flash bulb
  - D. Photoreceptors     \_\_\_ getting hit with a baseball  
                                  \_\_\_ eating a ice cream sundae  
                                  \_\_\_ getting kicked in the face
2. When excited, the Golgi tendon organ will cause the muscle to contract.
  - A. True
  - B. False
3. The cerebral cortex is responsible for controlling several major autonomic functions of the body, including respiration and circulation.
  - A. True
  - B. False
4. The Somatic Nervous System is most involved with producing muscle contractions during exercise?
  - A. True
  - B. False
5. The following information about sensory receptors and the stimuli they each respond to is accurate.

Mechanoreceptors – touch and pressure  
Nociceptors – pain  
Chemoreceptors – smell and taste  
Photoreceptors – Vision

  - A. True
  - B. False
6. The primary Motor Cortex contains representations of every muscle group in the body?
  - A. True
  - B. False

7. What are Golgi tendon organs and how do they help protect skeletal muscles?

- A. Cause the muscle to relax
- B. Tense the muscle
- C. Creates isometric contraction
- D. None of the above

8. Muscle spindles

- A. Relays information to the brain when a muscle is stretched
- B. Control motor unit recruitment
- C. Relay information to the brain relative to pain
- D. None of the above



# CHAPTER 7

# Muscle Contraction



# Muscle Contraction

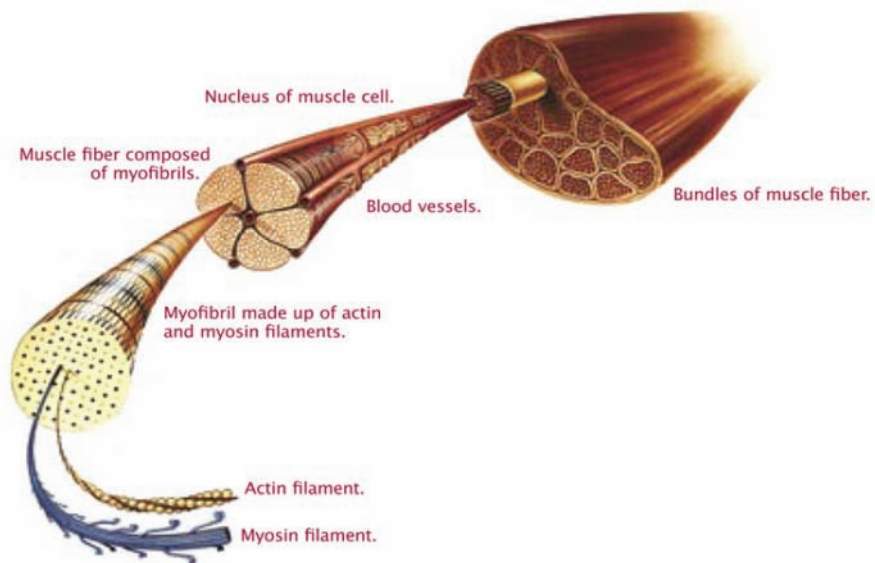


Figure 1.

## Myofibrils

The myofibrils are the contractile components that allow for strength and the performance of work. When the fiber is stimulated to contract, the myofibrils experience a contractile shortening and their circumference is increased. Myofibrils are comprised of the contractile proteins, **actin** and **myosin**, which actually slide over each other during contractions. Heavy, intense, low repetition resistance training has its primary effect on the actin and myosin. In fact, the process by which damaged actin and myosin are repaired is commonly known as hypertrophy “protein synthesis.” During heavy resistance training, the damage to the actin and myosin can be too extensive for complete repair, or it can be insufficient to stimulate adaptation. Therefore, the “controlled” damage and repair of them is the key to optimizing myofibril growth. This process can be likened to the repair of skin after being injured, resulting in scar tissue which is much stronger than the original tissue. Muscle is the same. The end result is a much larger and stronger myofibril component.

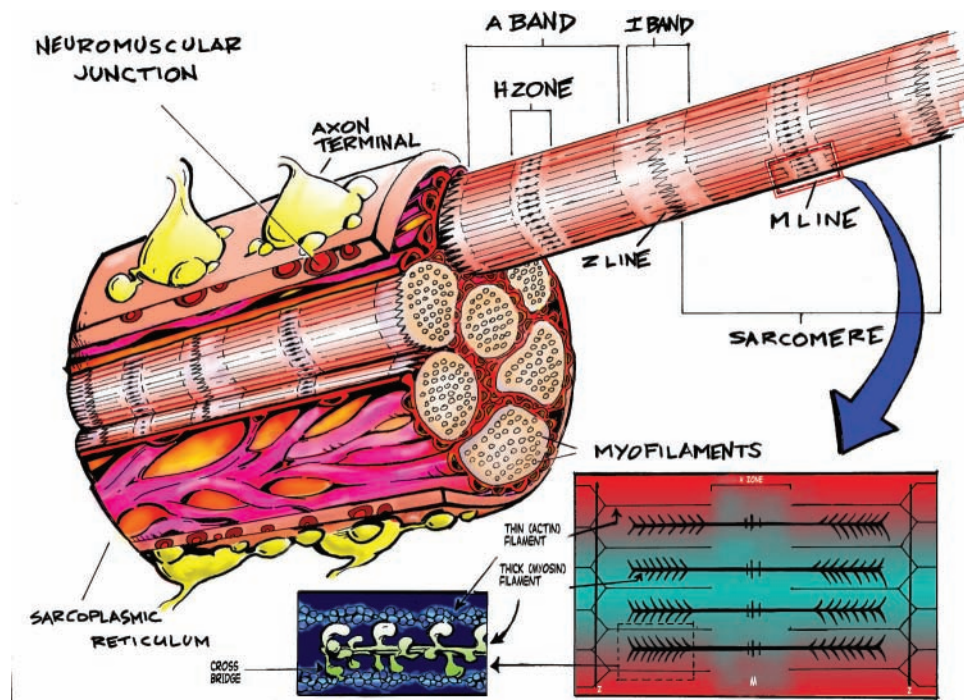


Figure 2

## Mitochondria

The mitochondria are located all along the myofibrils. They provide the energy a cell needs to move, divide, secrete and contract. They are commonly known as the “powerhouses,” or power centers of the cell. They are about the size of bacteria, but may have different shapes depending on the cell type. The mitochondria produce energy in the form of ATP, which is used during contractions, for daily activity, and recovery energy needs. Through regular and intense high repetition resistance training, the cell must adapt by building more mitochondria. This will boost cellular energy storage and ATP production capacity.

## Other Cellular Components

Unlike most other cells in the body, there are several nuclei in the muscle tissue cells. They are positioned all along the entire length of the muscle fiber and are embedded in the cell membrane, or Sarcolemma. The nuclei contain DNA. This DNA controls all cellular functions, and responds to various hormonal stimulations from the Pituitary, Adrenal, and Thyroid glands. The absence of this hormone stimulation would result in the inactivity and degeneration of the muscle tissue cell. The DNA transfers information from the nucleus to the mRNA housed in the nucleolus. The mRNA’s function is to take instructions from the DNA to the ribosomes. The ribosomes are the elements that actually manufacture protein. These ribosomes occur in the **Rough Sarcoplasmic Reticulum**. The Rough Sarcoplasmic Reticulum is located all along the length of the myofibril components. The ribosomes are the “assembly line” that actually builds and repairs the contractile proteins, actin and myosin, in the damaged myofibrils using available intracellular amino acids.

## Muscle Fiber

A muscle fiber (also technically known as a myocyte) is a single cell of a muscle. Muscle fibers contain many myofibrils. Muscle fibers are very long; a single fiber can reach a length of 30 cm. Muscle fibers can be grouped according to what kind of tissue they are found in skeletal muscle, cardiac muscle and smooth muscle. Skeletal muscle fibers can be further divided into two basic types: type I (slow twitch fibers) and type II (fast twitch fibers). The muscle cells of heart muscle tissue are called **cardiomyocytes**.

## Component Variation among Fiber Types

There are differences in the myofibrils and mitochondria of all three muscle tissue fibers. With regards to the myofibrils; there are a greater number and size of these components in the white, fast twitch muscle fibers than in the red, fast twitch muscle fibers, and a greater number and size in the red, fast twitch muscle fibers, than in the red, slow twitch muscle fibers.

## Muscle Composition

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. These muscle fibers are, in turn composed of tens of thousands of thread-like myofibrils, which can contract, relax, and elongate (lengthen). The myofibrils 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.

## Skeletal Muscle *(figure 3)*

There are seven types of skeletal muscle. The structure of a muscle is specific to its purpose and function. The types of skeletal muscle are:

- Fusiform - a muscle that has the shape of a spindle, which is wider in the middle and narrows at both ends. This allows for greater range of motion but limited strength.
- Quadrate - a muscle that is square shaped, with parallel fibers that run directly from origin to insertion
- Triangular - a wide origin that converges to a narrow insertion resembling a triangular shape.
- Pennate muscles - fibers run obliquely with respect to the tendon.
  - Unipennate - fibers are on the same side of the tendon
  - Bipennate - fibers on both sides of the central tendon
  - Multipennate - central tendon branches within a pennate muscle
- Longitudinal - parallel fibers consisting of tendinous intersections that run perpendicular to the direction of the fibers.

*Most skeletal muscles are either fusiform or pennate fibers.*

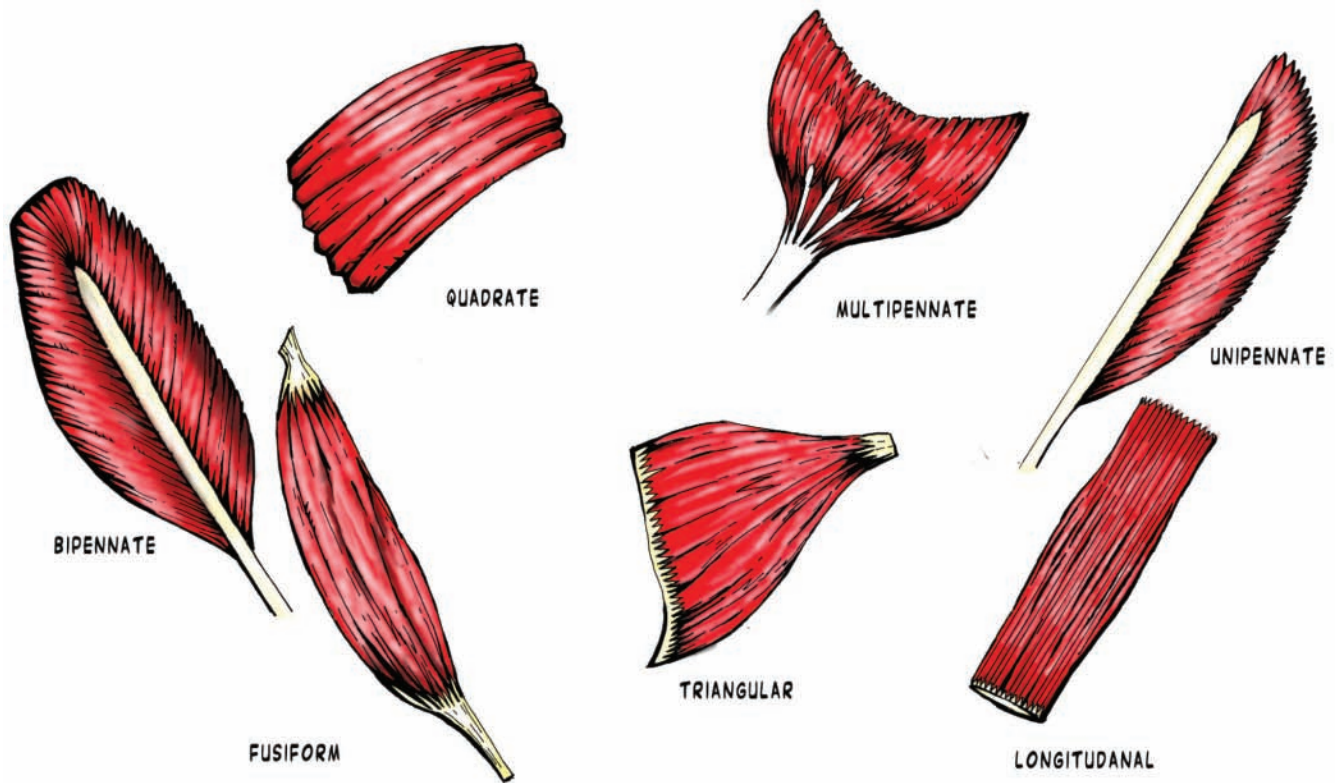


Figure 3. The seven types of skeletal fibres

Most skeletal muscles are either fusiform or pennate fibers.

### Muscle Fiber Types

As mentioned there are three types of muscle tissue; white fast twitch, red fast twitch and red slow twitch muscle fibers. These different fibers have exactly the same internal components, but vary in number and size. They have differing levels of a substance called myosin-ATPase, which breaks down ATP for energy. The more of this enzyme, the faster the contraction, thus more power as well. These fiber types have varying cardiovascular "support systems" and fuel-utilization characteristics, and have different types of nerves that stimulate them. Therefore, they are coordinated, or organized functionally, as well as structurally. The individual fiber is stimulated to contract by a branch of the neuron called an axon, which varies in thickness and the degree of myelination, or insulation it possesses. The thicker or more myelinated it is, the faster the signal can travel down it. For highly efficient aerobic metabolism to occur, oxygen must be present. This is delivered to the muscle cell by a very small tube called a capillary. Microscopic capillaries extend throughout intramuscular areas surrounding the muscle fibers.

### White, Fast Twitch Muscle Fibers - Type II b

White, fast twitch muscle fibers have fewer capillaries and, therefore, must rely on glycolysis for energy – thus, the name fast-glycolytic fibers. In the absence of this oxygen-rich blood supply, they cannot function for very long periods. However, as a lot of fibers are contained within the fast twitch motor unit, and the girth of the individual fiber is large, possessing more contractile proteins, they are extremely strong.

### **Red Fast Twitch Fibers - Type II a**

The red, fast twitch muscle fibers have a greater number of capillaries, and can, therefore, outlast the white, fast twitch fibers. But they don't have as much myosin-ATPase and, therefore, generate less tension. These muscle fibers are able to use either oxidative (aerobic) or glycolytic (anaerobic) metabolic pathways, and are called Fast Oxidative Glycolytic fibers. The long-distance Kenyans and some middle distance runners have high proportions of these fiber types.

### **Red, Slow Twitch Muscle Fibers - Type I**

The red, slow twitch muscle fibers have a tremendous number of capillaries which allow for long-term sustained activity. However, there are fewer fibers in each motor unit, and each fiber is thinner than its fast twitch cousins, so they produce less strength. To perform well, endurance athletes must have a high proportion of these. Training can have significant effects on the capacities of these fiber types, but in most cases cannot change the fiber types.

### **Coordination of Muscle Fiber Types to Motor Units**

All three muscle fibers occur within each muscle in genetically predetermined proportions. The muscles themselves will vary in the proportions of these fibers. For example, a postural muscle like the Soleus, which is used during standing to keep balance, has a high percentage of slow twitch fibers; whereas the gastrocnemius, just above it, is used for explosive jumps and is much higher in fast twitch fibers.

The white, fast twitch muscle fibers have very few mitochondria elements, thus restricting the duration of its contractions. The red, fast twitch muscle fibers have more mitochondria elements than the white fibers, meaning it can contract for longer periods prior to failing. The red, slow twitch muscle fibers have a tremendous number of mitochondria elements, allowing for sustained contractions for much longer periods than either of the other muscle fiber types.

### **Skeletal Muscle Tissue**

Roughly 40% of body Structure of muscle cell

- Elongated: length of muscle
- Multiple flattened nuclei along outer portion near sarcolemma
- Consists of bundles of fibers (myofibrils)
- Bundles of muscle fibers wrapped in connective tissue are called fasciculi
- Nerve connection to muscle belly called motor end plate.
- Myofibrils made of contractile proteins: actin (thin myofilaments) and myosin (thick myofilaments)
- Thin myofilaments also contain proteins **troponin** and **tropomyosin** which aid in contraction
- Actin connected to myosin through cross bridges
- Muscles that work together to produce a common movement: synergists
- Muscles that produce opposing movements: antagonists



## How Muscles Contract

Nerves connect the spinal column to the muscle. The nerve and muscles meet at the neuromuscular junction. Acetylcholine is released by the axon into the synapse, where it then stimulates the target sarcolemma. 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. Its main purpose is to move you. It connects to the bones, and makes them move or not. Tendons attach muscle to bone.

## Muscle Contraction

- Motor nerve cell (neuron) carries stimulus to motor end plate.
- Acetylcholine crosses the neuromuscular junction and stimulates sarcolemma.
- After acetylcholine reaches muscle fiber, it stimulates a release of calcium in the cell, which triggers action of the troponin and tropomyosin.
- Cross bridges pull thick and thin myofilaments over each other, shortening the length of entire fiber.
- One neuron may innervate up to one hundred muscle fibers.
- Motor unit: unit of muscle fibers innervated by one single neuron.
- The less muscle fibers innervated by one neuron, the more fine control over the muscle (fine movements).
- Force is generated in two ways: 1) increasing the amount of motor units firing; 2) increasing the speed of neuro-motor stimuli.

When a muscle is stimulated to work, it can only shorten. Muscles pull on the objects they are connected to.

## Concentric Contraction

- Muscle contraction as fibers shorten.
- Usually active, voluntary.

## Eccentric Contraction

- Muscles contract as fibers lengthen.
- Usually involuntary, in order to protect the joint.
- Usually antagonistic - purpose is to decelerate the agonist (this usually occurs at the end range of the joint).
- Strength training is more effective when includes eccentric actions.
- More muscle injuries occur during eccentric than concentric phase.

## Isotonic Contraction

- Muscle contraction with movement around the joint.

## Isometric Contraction

- Muscle contraction with no movement around the joint.

### **Isokinetic**

- Muscle contraction at a constant velocity.
- For example, pushing an object that cannot be moved.

### **Agonists**

- Muscle performing a particular action.

### **Antagonists**

- Muscles that act in opposition to the movement generated by the agonists.
- Responsible for returning a limb to its initial position.
- Reciprocal Inhibition (forced relaxation).
- Inhibited from contracting due to tight agonists.

### **Antagonistic Muscle Groups**

- Pectorals/latissimus dorsi.
- Anterior deltoids/posterior deltoids.
- Left and right external obliques.
- Quadriceps/hamstrings.
- Biceps/triceps.
- Forearm flexors/extensors.

### **Synergists**

- Smaller muscles providing assistance to the larger working muscle groups.

### **Stabilizers**

- Muscles providing stability in order for the agonist to perform.

The individual fiber is stimulated to contract by a branch of the neuron called an axon. If you could isolate and cut a cross section of an individual skeletal muscle cell fiber and look inside, you would see that it consists of several components, each having a specific function. Your training will be increase in productivity when you understand how to individually and intelligently affect the cell function.

### **Connective Tissue and Blood Supply**

The epimysium surrounds the entire muscle group with a sheath of connective, fibrous, and elastic tissue. The sheath of connective tissue surrounding a bundle of muscles, or motor unit, is called the perimysium, and the connective tissue surrounding each muscle cell fiber is the endomysium. These different fibers have differing cardiovascular "support systems." Microscopic capillaries extend throughout intramuscular areas surrounding all of these muscle tissue fibers. The white, fast twitch muscle fibers have very few capillaries, and in the absence of this nutrient rich blood supply, they cannot function for very long periods, but are extremely strong. The red, fast twitch muscle fibers have a greater number of capillaries, and can, therefore, outlast the white, fast twitch fibers, but are not nearly as strong. The red, slow twitch muscle fibers have a tremendous number of capillaries, allowing for long-term sustained activity, however, with very little strength.

## **Motor Units**

A motor unit is a single motor neuron plus all the muscle fibers to which it connects. Some motor neurons only connect to a few muscle fibers, while other motor neurons connect to hundreds of muscle fibers. All the muscle fibers randomly occur together in small bundles in genetically predetermined proportions. These bundles are called motor units and are named after the predominant type of fibers located in these motor units. If a motor unit is made up of predominantly white, fast twitch tissue fibers, that motor unit is called a white, fast twitch motor unit, and so on.

## **Motor Unit Function**

Generally speaking, white, fast twitch motor units are responsible for speed and strength, and a person who has a predominance of these would be best suited for strength events. The red, fast twitch motor units are responsible for sustaining a load over prolonged periods, and a person with a predominance of these motor units would be best suited for events requiring stamina, such as boxing, football, basketball, and so on. The red, slow twitch motor unit is responsible for producing energy over long periods, and a person with a predominance of these would be best suited for endurance events.

# **Motor Unit Recruitment Methods**

## **Immediate Recruitment**

As a general rule, only the minimum number of motor units required to move a given weight will contract in performing work. Pick up a very light object in your hand, bend your arm at the elbow, and feel the contracted bicep with your free hand. The muscle will feel somewhat soft because only the red, slow twitch motor units are contracting. The assistance of the remaining motor units is not required. If the resistance is slightly greater, the red, fast twitch motor units will assist the red, slow twitch motor units. Once again, for example, pick up a heavier object and feel the contracted bicep. It will feel harder than it felt when lifting the lighter object because more motor units are working. If the resistance is greater yet, the white, fast twitch motor units will finally assist in the work. This time, pick up a very heavy object, and not only will your bicep feel extremely hard, but you will also feel the strain against the resistance. In this case, most if not all, the motor units in the working muscle are involved. The immediate involvement of varying numbers of motor units based upon the amount of weight moved is one form of motor unit "recruitment." Immediately providing extremely heavy resistance will insure an earlier "recruitment" of the white, fast twitch motor units, which we know to have the greatest potential for growth. This also tells us that performing light resistance exercise will be of little value in optimizing growth. There is, however, still some growth stimulation of the red, fast and red, slow twitch motor units in lighter high repetition training. However, they can experience only limited growth by comparison, due to their tissues' differing composition, which will be discussed in greater detail later.



### **Depleting Energy Recruitment**

As a result of depleting energy, another type of motor unit recruitment occurs. For example, during contractions of a muscle group against light resistance, each repetition steadily depletes the working motor units of energy, and other motor units are called upon to assist the fatigued motor units in the same order as before. First the red, fast twitch motor units assist the already working slow twitch motor units. As the red, slow and red, fast twitch motor units are continuing to tire, the white, fast twitch motor units are called upon. By the time the white, fast twitch motor units start working, the entire muscle group is rapidly exhausting. It is also quite probable that by the time the white, fast twitch motor units are called upon, lactic acid and free phosphate are accumulating, thus inhibiting further contraction. This type of recruitment minimizes the involvement and growth stimulation of the white, fast twitch motor units, which are known to have the greatest potential for growth. To experience this type of motor unit recruitment, pick a relatively light weight and begin to perform repetitions. As the muscle becomes more and more fatigued, you will begin to notice a burning sensation, and a slight pump. As the exercise becomes more difficult, especially when performing a movement involving a very large amount of muscle tissue, such as the squat, your heart rate will become elevated and your breathing labored. As the movement becomes even more difficult with each repetition, there are more white, fast twitch motor units coming into play, since these motor units are reserved until last when the work is more strenuous. When you finish the set, after performing as many as 25 repetitions, the white, fast twitch motor units may only have performed optimally for two to three of those last repetitions. This is hardly enough to stimulate optimum involvement.

### **Contractile Speed Recruitment**

Yet another type of motor unit recruitment is based on the speed of contraction. A maximum contraction against a sub-maximal resistance will, in theory call on the red and white "fast twitch" motor units due to their faster contractile speeds. This can be accomplished through compensatory acceleration training, plyometrics, or by performing Olympic style weight lifting. Olympic style weight lifting has been applied to athletes for years by strength trainers. It is used more frequently when training for specific events requiring explosive types of movements, and without proper execution, can increase the risk of injury. Therefore, the frequency of this type of training should be controlled. It is the National Federation of Professional Trainer's (NFPT) position that the risk of injury far outweighs the benefits to be gained from Olympic lifting, especially among non-athletes or by athletes without the benefit of professional and experienced instruction. Non-load barring "plyometric" (multi-directional) training is the suggested option to enhancing power and speed.

## **Resistance Exercise and Contractile Failure**

### **Neuromuscular Failure (Power and Speed) (All Players)**

This type of failure results more in the enhancement of nerve impulse transmission rather than muscle strength and/or endurance. Examples of activities that involve neuromuscular failure include Olympic style lifting such as power cleans, cleans, jerks, clean and jerks, and other load barring compensatory acceleration activities. These training methods are also commonly referred to as being "ballistic." These exercises have been used in the past and are still used, with the

desired affect being the enhancement of speed and power through explosive muscle contraction lasting only a split second under extremely heavy loads. This trains the neuromuscular system, and not significantly the muscular system, because the duration of the contraction is too short to cause damage to muscles significant enough to result in growth and strength increase. These exercises should be done under supervision and are trained movements over time. Moreover, there is a high risk of injury associated with these “speed” and “power” activities. There is a “multi-directional” sports conditioning training methodology called “plyometrics” that accomplishes the carry over designed for on field performance. Plyometrics should be done after building appropriate strength, core control, joint integrity and proprioceptive awareness.

#### **Myofibril Failure 4-6 Reps (Size and Strength)**

The second of these four types of failure occurs if the resistance is so great that the contractile components fail prior to the depletion of available energy in the working muscles. These near “maximum contractions” will call upon the immediate recruitment, damage, and growth of existing myofibrils, especially in the white, fast twitch motor units. We’ll call this Myofibril Failure. The optimum repetition range to use for this effect is the four to six repetition range (this repetition range has been determined through independent research discussed elsewhere in this manual). Frequent performance of sets using fewer repetitions to failure can result in acute or accumulative damage to soft tissues. If you were to train to failure in the one to three repetition range over a long period of time, you may not outwardly feel pain from accumulative muscle tissue injury, but in reality, microscopic tears can occur in the tissues that require extended periods of time for adequate repair. The greater the damage, the larger the scar tissue, the larger the scar tissue, the more the scar will inhibit proper musculoskeletal function. This could then lead to a very serious acute injury to the muscle. One to three repetition sets should rarely, if ever, be performed, with the possible exception of competition or infrequent progress measurements. Damage to cartilage, ligaments and tendons is possible if you typically lock out joints at the top of heavy pushing movements, or fully extend at the start of heavy pulling movements, because in these positions, the above passive structures are supporting the weight.

#### **Intermediate Failure 12-15 Reps (Muscular Stamina)**

The third of these four reasons for contractile failure occurs when the contractile components are failing at, or about the same time as the short-term energy stores are depleted. This, in theory, will result in adaptation through the building of new myofibrils and mitochondria, especially in the red, fast twitch motor units. We will call this type of failure Intermediate Failure. The optimum repetition range to use for this affect is 12 to 15 repetitions. Sets of about 7 to 11 repetitions call on the participation of both white and red, fast twitch motor units. This should be avoided because neither type of motor unit will be optimally stressed.

#### **Mitochondrial Failure 20-25 Reps (Muscular Endurance)**

The fourth contractile failure type occurs as a result of depleted energy stores, and a subsequent accumulation of contraction inhibiting substances prior to causing any growth stimulating damage. This, in theory, will result in adaptation through the increased storage of energy, and the building of new mitochondria, especially in the red, slow twitch motor units. This type of failure Mitochondrial Failure. The optimum repetition range to use for this affect is 20 to 25 repetitions. Performing sets of 16 to 19 repetitions will once again call on the varying involvement of the red, fast and the red slow twitch motor units. This will not provide the optimum involvement of either of the two fiber type motor units individually.

## **Dispelling Common Myths**

All the tissue fibers within a motor unit will contract together because the entire motor unit is stimulated to contract by the same neuron, regardless of the angle of resistance (innervations). Movements should be selected that allow the target muscles to be stressed by the heaviest amount of weight possible, calling on the involvement of the greatest number of motor units possible (desired method of motor unit recruitment). Extremely heavy compound movements are said to have the greatest degree of leverage and should always be used in preference to partial isolation movements. It is important to once again realize that strict isolation is an anatomical impossibility since one muscle group cannot function on its own. All muscle tissue fibers run the entire length of the muscle group, from its origin to its insertion, and receive growth stimulation uniformly throughout their entire length. With this in mind, once again, it is physiologically impossible to shape a muscle. Muscle tissue structure and shape are strictly genetic.

## **Cardiac and Smooth Muscles**

Cardiac muscle refers to the heart itself. Smooth muscles include digestive, respiratory and vascular tissues. The digestive and respiratory tissues provide for the movement of nutrients and wastes for their uptake and excretion respectively, and will not be discussed in great detail here. Vascular tissue, or blood vessels, function in a variety of ways in response to exercise, adrenal hormone stimulation, and sympathetic nervous system stimulation will be discussed.

## **Cardiac Muscle Function & Resistance Exercise**

The cardiac muscle is similar in many ways to skeletal muscle. They are both striated and house the same cellular components in varying proportion. The heart muscle will adapt to resistance exercise in much the same way that skeletal muscles do. If the heart is forced to pump against an increased amount of resistance for prolonged periods, such as is common in resistance exercise, the cardiac tissue or heart muscle will most likely adapt by increasing in size and strength.

## CHAPTER 7

1. Myofibrils are the contractile components that allow for strength and the performance of work.
  - A. True
  - B. False
2. Actin and Myosin are proteins that work independently in the Myofibrils
  - A. True
  - B. False
3. What is ATP?
  - A. Energy
  - B. Protein
  - C. Fats
  - D. Carbohydrates
4. Which is NOT a muscle type description:
  - A. Skeletal
  - B. Cardiac
  - C. Respiratory
  - D. Smooth
5. Which one is not a muscle fiber type?
  - A. White fast twitch
  - B. White slow twitch
  - C. Red fast twitch
  - D. Red slow twitch
6. White fast twitch muscle fibers have a tremendous number of capillaries allowing for long-term sustained activity.
  - A. True
  - B. False
7. A motor unit is a single motor neuron plus all muscle fibers to which it connects.
  - A. True
  - B. False

8. Fast twitch motor units are responsible for
- A. Sustaining a load over a prolonged period
  - B. Speed and strength
  - C. Producing energy over long periods
  - D. Endurance
9. An example of neuromuscular failure is much more common in ballistic training methods?
- A. True
  - B. False
10. At what rep range does Myofibril failure commonly occur?
- A. 12-15
  - B. 4-6
  - C. 20-25
  - D. none of the above
11. What is a characteristic of Mitochondrial Failure?
- A. Contractile components are failing at or about the same time energy stores are depleted
  - B. Contractile components fail prior to depletion of available energy
  - C. Depleted energy stores and a subsequent accumulation of contraction inhibiting substances
  - D. All of the above

# CHAPTER 8

## The Energy Systems

## The Energy Systems

Bioenergetics, or the “energy systems,” refers to the metabolic pathways from which energy is made available for muscular contraction or work. Biological organisms, such as the human body, use chemical energy to power all the living systems. A suitable fuel is needed to create the chemical energy that allows the systems to carry out their normal functions and reach their main goal of energy production. Food sources can be broken down into three main components: carbohydrates, fats, and proteins. Carbohydrates are converted into glucose – an extremely powerful energy source within the biological system. When in excess, glucose is stored as glycogen in the liver and muscle tissue, or as body fat. During exercise, it is broken down so that it can be delivered to working muscle cells. Fats, or lipids, contain the most energy of the food sources. This is due to their chemical structure. Fat reserves are very high in relation to carbohydrates, which provides for a high energy capacity in the presence of low intensity exercise. We are concerned with the fats which are stored in the muscle as triglycerides. Protein, made up of amino acids, is broken down during digestion, and can also be used as a low power source when needed. Protein offers a much lower contribution in terms of energy than carbohydrates and fats, but holds more importance with muscle growth and cellular repair. Of these three sources of energy, only carbohydrates can be metabolized for energy without the direct involvement of oxygen.

In order to understand the bio-energy systems, one needs to have an understanding of the fundamental components of raw energy utilized by the musculoskeletal system. In the living cell, the main high-energy compound is adenosine triphosphate, or ATP. ATP is a complex compound stored in all cells, particularly muscle cells. It is required for the biochemical reactions of muscle contraction to take place. It is comprised of adenosine bonded to three phosphates. During muscular contraction, ATP is broken down on the chemical level. This results in the release of free energy, the presence of adenosine diphosphate (ADP), and a free inorganic phosphate. These are generated from the breaking of a phosphate bond to the ATP structure. The greater the demand placed on a muscle, the faster this breakdown of ATP will occur to create energy. During intense exercise, the ATP stored within the muscle cells is quickly depleted, and for continued muscular contractions to occur, this must be quickly replenished through some chemical means. The energy systems responsible for these chemical processes will further be discussed.

Creatine phosphate (CP) is a chemical compound stored in muscle and is important for replenishing ATP after the initial stores are exhausted. In this process, CP donates its phosphate to ADP in order to create ATP. In this way, the CP serves as an immediate source of high energy phosphate which can be used to replenish ATP. Because of its limited quantity, CP only contributes to ATP replenishment for the first few seconds of high intensity exercise.

Glycogen is considered to be the principle storage form of glucose and is mainly found in the liver and muscular tissues.

Now that the terminology has been covered, we can begin to examine the energy systems individually. Remember that ATP is necessary for all muscular contractions, and that during exercise, the ATP stored within the muscle is quickly depleted.

There are three major sources of high energy phosphate (ATP) that take part in the conservation, capture, and expenditure of free energy.

These three major chemical pathways, with their common names, are:

1. The phosphagen, anaerobic, anaerobic alactic, or ATP-CP system
2. Glycolysis, anaerobic lactate, or embden-meyerhof-parnas pathway. This can be broken down into two sub-categories:
  - A. Anaerobic glycolysis, fast glycolysis, lactic acid, or anaerobic lactate pathway
  - Aerobic glycolysis, or slow glycolysis pathway
3. The oxidative, aerobic, or aerobic respiration system.

The phosphagen system is an anaerobic process, in which no oxygen is present.

Glycolysis is the sequence of reactions that converts one molecule of glucose into pyruvate, with the concomitant production of a relatively small amount of ATP. The oxidative system, which takes place in the cell mitochondria, is the most productive source of ATP, but only functions when the body is abundant in oxygen.

As these three major pathways are explored, it should be noted that these systems all co-exist, and are active in overlapping energy expenditures. But the quality and quantity of their usage primarily depends on the intensity and duration of the demand put on the individual's musculoskeletal system. The energy systems help to replenish the depleted ATP as muscular demands develop during exercise. There is a direct relationship between the exercise intensity and duration, and the energy system that the body uses to supply energy. The following is a detailed description of each of the energy systems.

## The Phosphagen System

The **Phosphagen System** is active from rest to the beginning of all exercise, and is an instant source of ATP. This system provides energy at a very high rate, but only for a minimal duration of time. The main regulatory chemical reactions of the phosphagen system involve ATP and CP. Even though this system is very efficient when working; its duration limits its potential. There are very low amounts of ATP and CP stored within muscle tissues and cells. So continuous, long-duration activities are not sustainable before these stores are depleted, and in order to provide for the energy demands the phosphagen system needs to be supplemented by glycolysis or the oxidative systems<sup>2</sup>. It has been estimated that approximately 5 millimoles (mmoles) of ATP and 16 mmols of CP are stored in each kilogram of muscle<sup>3</sup>. When training the phosphagen system, one should understand that type II (fast twitch) muscle fibers contain greater concentrations of phosphagens than type I (slow twitch) fibers<sup>4</sup>. This fact would lead us to understand that, for certain exercises or sports, we should be specifically training this system. For example, if we are training a power lifter who has major demands on type II muscle fibers, and needs the explosive power and strength for a short duration of time, the phosphagen system is a major contributor to this athlete's performance.

The steps of the phosphagen system begin at the start of exercise when ATP is hydrolyzed by the enzyme myosin ATPase to ADP, organic phosphate and energy. This immediate energy is released for muscular contraction, although an increased ADP concentration activates creatine kinase, catalyzing the formation of ATP from the breakdown of CP. As exercise continues at high



intensity, creatine kinase activity remains elevated, and leads us into the next system of anaerobic glycolysis. As exercise intensity decreases, and depending on the level of oxygen in the muscle cells, aerobic glycolysis, or oxidative systems take over.

This system can fully recover ATP in three to five minutes, and it takes about eight minutes for complete CP resynthesis. Aerobic metabolism is largely responsible for the recovery of phosphagens.

## Glycolysis

**Glycolysis** is a system that focuses on the breakdown of carbohydrates to create the high energy phosphate ATP. The sarcoplasm (cytoplasm of muscle cell) is where the steps and reactions of glycolysis take place. This pathway is composed of ten reactions, ending with pyruvate, which can be used within the oxidative (aerobic) system, or lactate which can be used in the lactic acid (anaerobic) system. This metabolic pathway transforms glucose to pyruvic or lactic acid, and yields two molecules of ATP. Glycolysis enhances and supplements the phosphagen system, and also acts as a pre-cursor to the oxidative (aerobic) and lactic acid (anaerobic glycolysis) systems.

Due to the ability to perform with or without the use of oxygen, glycolysis can be broken down into two distinct directions of the pathway. The two separate directions lead to slow and fast glycolysis. Aerobic glycolysis, or “slow glycolysis,” is the process where pyruvate is transported to the mitochondria for use in the oxidative system. This branch of the glycolysis pathway is primarily used when there are adequate amounts of oxygen present within the mitochondria, and the individual’s energy demands are moderate to high. When muscle tension, or contraction occurs with brief periods of relaxation, oxygen uptake from outside the cell can be used to assist pyruvate in producing more ATP. This process is only used after the phosphagen system has depleted its ATP stores, the intensity is minimal to moderate, and the duration is long. For this system to take effect, there also has to be an adequate level of oxygen within the mitochondria. Anaerobic glycolysis, or “fast glycolysis,” uses pyruvate, and converts it to lactic acid. The end product is ATP at a higher rate. This branch of the glycolysis pathway primarily functions when there is an intense demand, although sub-maximal, and high energy is needed, and there is a limited or reduced level of oxygen in the cells.

Muscle glycogen can be replenished within 24 hours of exercise. This greatly depends on post exercise meals. It is suggested that carbohydrates be ingested every two hours after exercise for up to six hours.

## The Oxidative System (Aerobic)

Fats and carbohydrates are the main power source in the **oxidative system**. Protein is another source of energy, although its use is limited to when the musculoskeletal system has been completely depleted of fat and carbohydrate stores, and the body is at its limit of starvation in the muscle tissue. If this occurs, protein is used when the energy system is pushed past a threshold of greater than 90 minutes. The duration and intensity of the exercise determines which source is used. Fats are primarily used at the starting phase of the oxidative system. As the intensity increases, a switch to carbohydrates takes place. Finally, during long term maximal exercise, the system switches back over to fats, and possibly protein, as the primary energy.

Again, protein will only be used at the level of complete muscular starvation and depletion. At the end stages of glycolysis, the final product of pyruvate is taken to the mitochondria, and when there are sufficient levels of oxygen in the cells, begins the Krebs's cycle (Citric Acid Cycle, or tricarboxylic acid cycle).

**The Krebs cycle** (also known as the citric acid cycle, tricarboxylic acid cycle or TCA cycle) is a crucial component of the oxidative system. It is a portion of the oxidative pathway in which a series of chemical reactions in the presence of oxygen produce energy in the musculoskeletal system. This cycle does not actually use oxygen *per se*. The end products are extracted in the presence of oxygen by oxidative phosphorylation in order to access the potential energy in storage within the cycle. As we have previously mentioned aerobic glycolysis breaks down carbohydrates in the form of glucose into pyruvate, which, to enter the Krebs cycle, must move into the mitochondria where it is then converted into acetyl-CoA. A series of reactions occurs through the Krebs cycle, and 12 high energy phosphate bonds are produced. The phosphorylation of one glucose molecule results in the creation of 38 ATP units. The Krebs cycle is the end process where carbohydrates, fat and protein metabolism are directed. This system is the most efficient and quantitative producer of ATP for energy, but has limiting factors such as the need for oxygen, long duration, and minimal intensity.

## Lactic Acid

Lactic acid is a chemical byproduct of pyruvic acid, and is produced from the breakdown of glucose. It is seen as an end product of anaerobic glycolysis. Lactic acid accumulation within the muscular tissue is said to inhibit the contraction of muscle fiber. This fact is now being challenged.

The thought of lactic acid being a fatigue producing substance is now being challenged. Dr. George A Brooks, a Professor in the Department of Integrative Biology at the University of California Berkeley states, "It's one of the classic mistakes in the history of science." More evidence is mounting that lactic acid is actually fuel for our muscles. Now, the understanding is that muscle cells convert glucose, or glycogen to lactic acid. The lactic acid is taken up and used as a fuel by mitochondria, the energy factories in muscle cells. The idea that lactic acid causes DOMS (Delayed Onset Muscle Soreness) one to two days after training is thoroughly incorrect, as lactic acid is gone from your muscles within one hour post exercise.

Metabolic acidosis is when the pH is lowered because of exercise. This decrease in pH can diminish the work rate of the cells' energy system. This may be what is really responsible for muscle fatigue.

## What is the Most Efficient System?

As stated, the systems work together, and at no resting state or exercise level is there one system that completes the total energy production. When dealing with energy systems, the

emphasis is on the dominating system. No activity, whether it's a gentle stroll or a high-intensity sprint, exclusively uses one energy system, they all make a contribution depending on the length of time the exercise is performed, the level of energy expenditure, and the availability of oxygen. Exercise intensity is particularly important in determining the muscles' best energy source, and to what extent anaerobic or oxidative systems are primarily functioning.

A balanced program should include all training of all energy systems. (Speed training is a major category, but is generally practiced by competitive athletes only.)

### Rules for Any Exercise Method

A few simple rules are helpful as you develop your own routine:

- Don't eat two hours before vigorous exercise.
- Drink plenty of fluids before, during, and after a workout.
- Adjust activity according to the weather, and reduce it when fatigued or ill.
- When exercising, listen to the body's warning symptoms, and consult a physician if exercise induces chest pain, irregular heartbeat, undue fatigue, nausea, unexpected breathlessness, or light-headedness.

**Warm-Up and Cool-Down Period.** Warming up and cooling down are important parts of any exercise routine. They aid the body in making the transition from rest to activity and back again, and can help prevent soreness or injury, especially in older people.

- Warm-up exercises should be practiced for at least eight to ten minutes at the beginning of an exercise session. Older people need a longer period to warm up their muscles. Low-level aerobic exercise is the best approach, such as dynamic warm ups, walking briskly, swinging the arms, or jogging in place.
- To cool down, one should walk slowly until the heart rate is 10 to 15 beats above resting rate. Stopping too suddenly can sharply reduce blood pressure, is a danger for older people, and may cause muscle cramping.
- Static stretching is appropriate for the cooling down period, but not for warming up because it can injure cold muscles. Particular exercises may require stretching specific muscles. For example, a jogger or biker might emphasize stretching the hamstrings, calves, groin, and quadriceps, while swimmers would focus on the groin, shoulders, and back.

The **phosphagen system** is typically in use with maximal, explosive effort and is very short in duration. Rest periods from five to seven minutes are crucial, because almost complete recovery of the muscle is needed to reset the phosphagen system, and to again reach maximal muscle goals. The bottom line is that a well-rested muscle will allow maximal effort to be reached. Examples of usage of this system include:

- Estoteric exercises (strong men competitions)
- Power lifting (heavy bench, heavy squat, and heavy deadlift)
- Olympic lifting (snatch, clean and jerk, power clean)
- High Jump
- Sprints
- Bound like sports (football, basketball, volleyball, soccer)

Glycolysis requires a sub-maximal effort, and is typically in use after the phosphagen energy stores have been depleted. As with the phosphagen system, sufficient rest periods are needed to return muscle almost to a resting state as this will enable the athlete to acquire maximal effort on the next major energy expenditure. The levels of rest should be within the realms of two to six minutes, because even though the glycolysis system deals with explosive power just like the phosphagen system, the levels are slightly sub-maximal in the glycolysis training principles. Examples of glycolysis usage in exercise are:

- Wrestling
- UFC (Ultimate Fighting Championship) training
- 200/400 meter run
- 50/100 meter swimming

Aerobic glycolysis, into the oxidative system, will be in use when enough oxygen is present. The requirements involve low intensity with long duration, mainly because ATP recovery is very high. Rest periods are near minimal in these pathways because of the low intensity over a long period of time. If rest periods are used, they should be in the realm of 0 to 90 seconds, followed by immediate return to the exercise. Examples of oxidative usage in exercise are:

- Distance or marathon running
- Cross country skiing

## Understanding and Application of the Systems to Training

Applying energy systems to some sports can become quite complicated. It's easiest to look at basic running events first...

### 100m Sprint

Top athletes run this event regularly under 10 seconds. The **Phosphagen** energy system powers a sprinter for most of the race. If you watch a slow motion replay of a 100m sprinter, you will notice that their respirations are low or even non-existent during the sprint. With pursed lips, their face is a picture of concentration, and all of their energy production is from anaerobic processes that occur without oxygen.

### 800m Run

Just as with the 100m, an athlete is powered by the **Phosphagen** energy system for the first few seconds of the race. As the athlete is not running at maximal intensity, the stores of ATP will last a few seconds longer. **Anaerobic Glycolysis** then predominates for the rest of the race,

although beginning stages of **Aerobic Glycolysis** make a small contribution.

### **Half Marathon**

The **Oxidative-aerobic** system makes the greatest contribution to this event. The **Phosphagen** and **Glycolysis** (anaerobic and aerobic glycolysis) energy systems will predominate during the first one to two minutes of the race and in a sprint finish. What determines whether the athlete is 'burning' carbohydrate, fat or protein during the run? Well, at rest, 70% of the ATP produced is derived from fats, and 30% from carbohydrates. As the aerobic system begins to predominate, fats turn over to carbohydrates (ultimate efficient fuel) and make the greatest contribution to energy production at 100%. Primarily fat will begin as the energy source, but as exercise intensity is relatively low and constant, carbohydrates will last for a while. There will then be a switch back to fat as the carbohydrate stores are depleted. Fat will be relied on more as the duration of the race increases, until the duration reaches greater than 90 minutes. Here, the fat and carbohydrate stores have been depleted in the muscles, so protein may be slightly used. Carbohydrates are the most efficient source, but cannot always be relied upon. Again, the body does not suddenly switch from one substrate to another – the cross over is a gradual shift.

### **Multi Sprint Sports**

So far the examples have been straight forward. What about multi-sprint sports like football, basketball, soccer, hockey and tennis? In short, **all three energy systems** make a significant contribution. This athlete uses the **phosphagen** system to jump, throw and sprint, while the **anaerobic glycolysis** system is taxed if the player has to make several back-to-back sprints. And of course the **aerobic glycolysis-oxidative-aerobic** systems contribute for the entire duration of the game, as the levels of duration increase.

### **Quick Summary**

Phosphagen: 0 to 6 seconds, and is dominant from resting to near maximum intensity

Phosphagen and anaerobic glycolysis: 6 to 30 seconds, dominant at near maximum intensity

Aerobic glycolysis: 30 seconds to 2 minutes, maximum intensity

Aerobic glycolysis and start of aerobic system: 2 to 3 minutes at moderate intensity

Aerobic system: over 3 minutes at light intensity

## **Manipulating the Energy Systems for Training Goals**

The strength and conditioning professional's ultimate goal is to manipulate the systems to create the ultimate performance of the athlete for exercise, sport, or competition. The main factors to specifically manipulate are, **intensity, duration, rest, and sport specificity**. The systems, with examples of training variables focusing on specific training for the chosen energy system, are as follows:

### **Phosphagen Energy System**

- Sprints, 12 x 20m with recovery of 2 minutes recovery between repetitions.
- Sprints, 5 x 60m with 6 minutes recovery between repetitions.
- 8 x 30m shuttle runs with 2 minutes recovery between repetitions.
- Resistance training of 3 sets of 3 repetitions at 90% 1rm, with 5 minutes rest between sets. The intensity should be done 2 to 4 times per week for maximal performance of the phosphagen system.

### **Glycolysis Energy System**

- Distance sprints, 5 to 8 x 300m, with 5 minutes recovery between repetitions.
- 150m intervals at 400m pace with 3 minutes recovery between repetitions, until pace slows significantly.
- Long distance sprints, 6 x 500m with 3 minutes recovery between reps.

### **Oxidative Energy System**

- 4 to 6 sets of 2 to 5 minute runs, with 2 to 5 minute recovery between intervals.
- 10 sets of 400m runs, with 60 to 90 seconds recovery between intervals.
- Long distance 5 to 10 km runs.

## CHAPTER 8

1. Glycolysis can be broken down into two distinct directions of the metabolic pathway due to?
  - A. The ability to mainly use protein as the primary energy.
  - B. The end products being extracted in the presence of oxygen.
  - C. The ability to perform with or without the use of oxygen.
  - D. None of the above.
2. A chemical compound stored in muscle that is important for replenishing ATP after the initial stores are exhausted?
  - A. Lactic acid
  - B. Creatine phosphate
  - C. Adenosine triphosphate
  - D. Pyruvic acid
3. What is produced from the breakdown of glucose and seen as an end product of anaerobic glycolysis?
  - A. Lactic acid
  - B. ATP
  - C. Glycogen
  - D. Phosphogen
4. Glycogen is stored in the?
  - A. Mitochondria
  - B. Liver and muscular tissues
  - C. Golgi Tendon Organ
  - D. All of the above
5. Which system is an instant source of ATP for energy?
  - A. Krebs cycle
  - B. Phosphagen energy system
  - C. Glycolysis
  - D. none of the above
6. What systems are involved in a multi sprint sport such as basketball & football?
  - A. Phosphagen
  - B. Glycolysis
  - C. Oxidative
  - D. All of the above
7. The Oxidative system makes the greatest contribution to which event?
  - A. 800m run
  - B. 100 m sprint
  - C. Half marathon
  - D. Multi sprint sports

8. Resistance exercise is:
- A. Aerobic
  - B. Anaerobic (strength)
  - C. Isometric
  - D. Plyometric
9. What is the correct progression of an exercise routine
- A. Static Stretching, Warm-up, Anaerobic/Aerobic workout, cool down
  - B. Warm-up, Static Stretches, Anaerobic/Aerobic workout, cool down
  - C. Warm-up, Anaerobic/Aerobic workout, cool down, static stretch
  - D. Static Stretching, Anaerobic/Aerobic workout, static stretch, cool down
10. In the living cell, the main high energy compound is
- A. Creatine
  - B. ATP
  - C. Glycogen
  - D. ADP
11. During muscular contraction ATP is broken down into what substance
- A. ADP
  - B. ATP
  - C. Glycogen
  - D. none of the above
12. The Phosphagen system is an
- A. Anaerobic process
  - B. Aerobic process
  - C. Oxidative process
  - D. both b and c
13. Lactic acid is a byproduct of
- A. Pyruvic acid
  - B. Metabolic acidosis
  - C. Glycolysis
  - D. all of the above





# CHAPTER 9

## **Basic Conditions**

It is important to know some basic conditions and terms.

**Spina Bifida** – birth defect caused by an incomplete closure of one or more vertebral arches of the spine. There are different levels of severity, ranging from benign and clinically insignificant, to severe and life threatening malformations of the spinal cord. The spinal membranes and cord may protrude through the absence of vertebral arches (called clefts).

**Basic Recommendations:** Extension is bad, neutral spine is bad.

**Spondylolisthesis** – translation of a superior vertebrae in relation to its inferior segment. This may, or may not be caused by instability, and it is essential to rule out instability. This may be caused by degenerative changes of the facet joints and intervertebral discs, or by congenital or traumatic disruption of the pars interarticularis of the upper of the two vertebrae. It most commonly occurs in the lumbar spine.

**Basic Recommendations:** Refer to a doctor for evaluation and diagnostic imaging to rule out instability. Avoid lumbar extension in most cases. Flexion feels okay but may make things worse. Emphasize a neutral spine during functional movements. Follow doctor's guidelines.

**Stenosis** – abnormal narrowing in an anatomic tube structure. Our focus will be spinal stenosis, which is narrowing of the spinal canal or intervertebral foramina. This is due to degenerative changes of the facet joints, uncovertebral joints and intervertebral discs. This is often accompanied by neurological symptoms.

**Basic Recommendations:** Slight flexion feels better but may make things worse. Follow the doctors guidelines on this one.

**Herniated Disc** – pathological condition in which a tear in the outer, fibrous ring (*annulus fibrosus*) of an intervertebral disc allows the soft, central portion (*nucleus pulposus*) to be extruded towards the outside.

Normally it is a further development of a previously existing disc protrusion or bulge. This is a condition in which the outermost layers of the *annulus fibrosus* are still intact, but tears on the inner layers will allow the nucleus pulposus to create a bulge when the disc is under pressure.

**Basic Recommendations:** spinal sparing techniques, core stabilization, balance and proprioceptive training. It is important to work within the client's boundaries and to communicate with their treatment provider in order to set guidelines for exercise prescription.

**Impingement** – refers to closure of a space through which a nerve, tendon, or blood vessel may run, causing friction and disrupting the structure's movement or position. A nerve impingement, such as carpal tunnel syndrome is a condition in which the nerve becomes trapped in the tunnel by scar tissue, degenerative changes and/or inflammation. This is different from a primary glenohumeral impingement, in which the acromion process develops a spike-like projection that frays the supraspinatus tendon below it.

**Basic recommendations:** Nerve impingement – neural flossing. Glenohumeral impingement – scapular stabilization. Flexibility of the prime movers.

**Spinal Fusion-** also known as *spondylosyndesis*, is a surgical technique used to fuse together two or more vertebrae. Supplementary bone tissue or metallic devices are used to fixate the segments.

**Basic recommendations:** proprioceptive and balance training, extremity flexibility and spinal stability. Avoid excessive end-range motions of the spine, particularly in flexion and rotation.

**Antalgia**– simply means leaning away from pain. Antalgic leaning patterns may present in any plane of motion.

**Basic recommendations:** Always refer to a doctor.

**Hyperlordosis** – excessive curve in the lumbar spine.

**Hypolordosis** – straightening of the lordotic curve in the lumbar or cervical spine.

**Hyperkyphosis** – excessive thoracic kyphotic curve.

### **Pelvic tilting**

**Anterior pelvic tilt** – position of pelvis is determined by the ASIS, which is pointed anterior (forward). This is usually associated with hyperlordosis, or hyperextension, of the lumbar spine. The glutes stick out.

**Posterior Pelvic tilt** – position of pelvis is determined by the ASIS, which is shifted posteriorly (back). This is usually associated with hypolordosis, or flexion of the lumbar spine.

**Neutral spine** – midway balanced point of the spine that requires the least amount of muscular contraction.

## CHAPTER 9

1. If a client has a spinal fusion you should do only rotational exercises?
  - A. True
  - B. False
  
2. After doctor clearance your client with a herniated disk should do Flexion exercises?
  - A. True
  - B. False
  
3. Hypolordosis means
  - A. Too much flexion
  - B. Straightening of the lumbar or cervical curve
  - C. Excessive lumbar or cervical curve
  - D. None of the above
  
4. A posterior pelvic tilt is when your belt buckle is tipped upward towards the belly button?
  - A. True
  - B. False
  
5. A herniated disk is when the disk is
  - A. Healthy
  - B. Stable
  - C. Bulging out from the vertebrae
  - D. None of the above

# CHAPTER 10

## Stretching

# Stretching

Stretching is a very important part of a training program, but unfortunately, it is often overlooked. Lack of flexibility is at the root of many problems. When a muscle is hypertonic, it is limited in its ability to contract and lengthen properly, causing inefficient movements and joint stress. They are also more likely to contribute to faulty biomechanics. Appropriate stretching and moderate exercise may prevent many musculoskeletal injuries prevalent in today's society. Stretching and strengthening, when implemented appropriately, produce a solid foundation for healthy biomechanics. Without this foundation, biomechanics and movement patterns will become inefficient, leaving one, not only performing at a less-than-optimal level, but with a possible increased risk of injury.

Arbitrarily increasing the joints' range of motion without considering the individual and the tasks they need to perform may be detrimental. Studies have shown a decrease in muscle power output and increased muscle reaction time following a stretch. Stretching certain muscle groups may be contraindicated when strength and/or power are required of them during the activity.

In some instances, a decreased range of motion of the body will enhance performance. An example would be the torso of a sprinter. Energy derived from the ground is transferred to the trunk by the lower extremities. Some of this energy can be lost to excessive lengthening of the trunk musculature. Therefore, in order to develop a training program that will improve upon the desired results, it is important to understand specific motion patterns. Furthermore, there is no evidence that stretching decreases the risk of injury. In fact, work by Dr. Stuart McGill has shown that the low back range of motion of injured workers had little relationship with their return to work. Also, a negative correlation between low back flexibility and back injury has been documented. Muscle injury (tear/strain etc.) rarely occurs at end ranges, discrediting the notion that stretching decreases the risk of soft tissue injury. Therefore, a training/stretching program must be tailored for each individual/athlete, and the tasks they need to perform.

## Precautions

Always consult a health care professional before initiating a stretch program. Stretching can be dangerous in the presence of musculoskeletal injury or disease. It is also important to warm up muscles before stretching them. Stretching a cold muscle can result in injury.

## Problems with static stretching prior to exercise

- Scientific evidence demonstrates that static stretching of muscle decreases isometric and dynamic muscle strengths at different velocities.
- Isometric strength is important for stability during complex movements.
- Dynamic strength has obvious importance when it comes to actual movement.
- In plain English, this means you will be slower and weaker on tasks that are fundamental to high-level performance.

## **Static Stretching Acutely Impairs:**

- Slow-speed, High Force Movements (Power lifting)
- High-speed, Lower Force Movements (Jumping & Sprinting)
- Research also demonstrates that balance, reaction time and overall movement time are negatively affected.
- Endurance athletes will be interested to know that static stretching also reduces muscular endurance.
- Static stretching some muscles before activity may be required if they are so tight they impede movement. Usually the Psoas and the Scalenes fall into this category. There are always exceptions to the rule so be aware of client needs.

### **Two Factors:**

1. Muscle/Tendon
2. Neuromuscular

### **Muscle/Tendon**

- Prolonged stretching can actually make the muscle and tendon overly compliant.
- Whenever we want to develop force in a muscle, it is important that we have plenty of stiffness as this allows for better use of stored, elastic energy in the muscle and tendon, and ensures that everything lines up properly at the level of the muscle fibers.

### **Nervous System**

- Due to motor control and reflex sensitivity, stretching makes it harder for the nervous system to tell the muscle to fire.

## **Static Stretching has its benefits:**

### **Post Workout:**

- Relaxation
- Increase or maintain a particular range of motion
- After weight training
- After walking/running
- After aerobic activity



# Stretching Principles

## The Stretch Reflex

The stretch reflex is the neurological process with which the body responds to a sudden change in the length of a muscle. This pathway includes the muscle fibers, receptors, and sensory and motor neurons of the spinal cord.

Stretch receptors (muscle spindles) are located within the sarcomere, or muscle cell. When lengthened they send a signal to the spinal cord through sensory neurons. These neurons synapse, or transfer the signal to motor neurons that control the muscle being stretched. This causes contraction of the muscle in order to maintain its resting length.

## Autogenic Inhibition

Autogenic inhibition is the neurological process whereby proprioceptors (golgi tendon organs), located at the musculotendinous junction, detect an increase in tension in that muscle. When a certain amount of tension is detected, the muscle is then inhibited in the spinal cord, preventing it from contracting. As a result, it will relax.

## Reciprocal Inhibition

Reciprocal inhibition is the process by which the contraction of an antagonist muscle neurologically inhibits the contraction of the agonist muscle. This occurs as a motor neuron that causes contraction in the antagonist muscle synapses transfers its signal to an inhibitory neuron that will inhibit the antagonist muscle. In other words, the antagonist muscle will relax or be prevented from contracting.

Reciprocal inhibition may also contribute to muscle imbalances. If an agonist muscle is hypertonic, or overactive, its antagonist will be inhibited, causing lengthening and a decrease in functional control. This will further allow the agonist to tighten, or shorten, creating a cyclical pattern of dysfunction.

# Types of Stretching

## Static Stretching

Static stretching is slow, and involves holding the end point of tension for 30 to 40 seconds. This type of stretch targets the passive elastic component of the muscles.

## Passive Stretching

A passive stretch is achieved by having an external force, such as a partner's push, wall, floor, machine, etc, applied in order to attain and hold the end position. Using a well-trained partner can help to achieve greater range of motion (ROM), and also to target specific muscle groups.

## Active Stretching

Active stretching uses agonist muscle contraction in order to stretch antagonist muscles. This type of stretching uses the principle of reciprocal inhibition.

## **Dynamic Stretching**

Dynamic stretching uses active contraction of the antagonist muscle (creating motion) in order to produce a stretch to the agonist muscle. This type of stretch targets the series elastic component of the muscles. Yamaguchi and Ishi have demonstrated an increase in power during leg extensions following dynamic stretching. This may be due to the rhythmic contraction of antagonist muscles raising the temperature, and to post activation potentiation; improvement in muscular performance following contraction. This study was only performed on recreationally active men, and not athletes. Therefore, the effect of dynamic stretching on power is not known in competitive athletes.

## **Ballistic Stretching**

Ballistic stretching involves active motion through a joint, and creating a bouncing motion at the end range of the stretched tissue. The goal is for the bouncing to cause an increase in motion past its end range on every repetition. This type of stretching may be detrimental to the target or surrounding tissues. It is not suggested to repeatedly force a joint, or a soft tissue through its end range, as this could cause irreversible laxity and instability in the non-contractile tissues of the joint (ligaments, joint capsule).

This could also activate the stretch reflex, which would in turn cause the target muscle to respond by contracting, or tightening. This type of stretching is associated with injury and is only recommended under careful guidance of a professional.

# **Proprioceptive Neuromuscular Facilitation Stretching**

Proprioceptive Neuromuscular Facilitation (PNF) includes four different types of stretching techniques. These combine muscle contraction and relaxation in order to relax an overactive muscle and/or enhance the flexibility of a shortened muscle. PNF was developed by Herman Kabat MD, PhD, Margaret Knott PT and Dorothy Voss PT in the 1940s to treat paralysis patients. Over the years, other forms of PNF were developed for the treatment of orthopedic, as well as neurologic, disorders.

## **Post Facilitation Stretch**

1. Target muscle is placed in midposition
  - Midrange of the muscle's full contraction
2. Patient contracts isometrically for 10 seconds using maximum strength
  - Therapist must not allow muscle to bounce – positioning and leverage are key
3. Relaxation phase
  - Patient is instructed to let go
  - Therapist immediately stretches muscle
  - Patient may have to practice how to let go immediately
4. Stretch
  - Muscle is held at new barrier for 10 seconds
5. Repeat at new barrier
  - If no increase in ROM was achieved, start at midposition
  - \*Increase in ROM due to autogenic inhibition

### **Post Isometric Relaxation (PIR)**

1. Engage barrier
  - This is done by lengthening the muscle until slight resistance is met
2. Isometric contraction
  - Patient is told to exert slight resistance (10-20% muscle contraction force) in the opposite direction
  - This is held for 10 seconds
  - It is important that the contraction is isometric, therefore, no movement must take place
3. Relaxation phase
  - Patient is instructed to relax
  - Wait at barrier for muscle to release and then initiate stretch
4. Stretch
  - Stretch until the next barrier is met and hold for 10 seconds
5. Repeat at new barrier
  - \*Increase in ROM due to autogenic inhibition

### **PIR With Agonist Contraction**

1. Same as PIR
2. Same as PIR
3. Agonist contraction
  - Following the isometric contraction, the agonist muscle is contracted as the target muscle is taken to its new barrier.
4. Repeat at new barrier
  - \*Increase in ROM due to reciprocal and autogenic inhibition

### **Contract-relax**

1. Same as PIR
2. Concentric contraction
  - Target muscle is contracted through its full ROM against resistance.
3. Relaxation phase
  - Patient is instructed to relax and let go
4. Stretch
  - Stretch until next barrier is met and hold for 10 seconds
5. Repeat at new barrier.
  - \*Increase in ROM due to autogenic inhibition

**Note:** It was assumed that the increased ROM of the muscle was based on muscle fatigue, reciprocal inhibition, muscle spindles, golgi tendon organs, and so on. However, EMG studies have shown significant activity in stretched muscles after their contraction in PNF-type techniques. Therefore, this increased ROM cannot be solely attributed to relaxation. It has been theorized that actively stretching allows the subject to feel as if they have more control, and as a result are more willing to extend their tissues into greater ranges.

### **Cramps**

Muscle cramps are involuntary and often painful contractions of the muscles, resulting in shortening. It is a common misconception that cramps originate in the muscle itself, and that the

muscle fires randomly. In actuality, cramps have been found to be a primarily neurological activity in which the motor neuron that controls a muscle fiber fires at a high frequency, causing this involuntary contraction.

#### **Some Causes of Cramps May Be:**

- Heavy exercise
- Pregnancy
- Hypothyroidism
- Depleted magnesium or calcium stores or other metabolic abnormalities
- Alcohol consumption
- Kidney failure leading to uremia
- Medications
- Muscle fatigue
- Dehydration

Although cramps may be benign, it is important to note that they may also be red flags of serious neurological, endocrine or metabolic disorders. Cramping should always be evaluated by a professional.

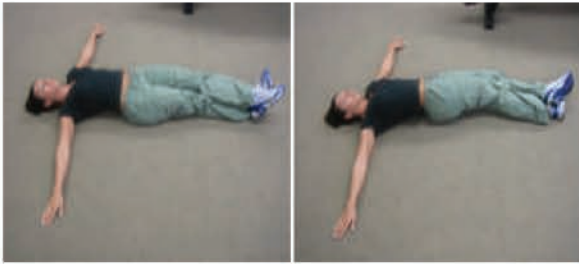
#### **Fasciculations**

Fasciculations are single, involuntary firings of motor neurons that will cause brief twitches in the muscle fibers that they innervate. These twitches usually are low in intensity, and will usually not produce motion at a joint.

Like cramps, many fasciculations are benign and do not indicate pathology. It is very common for healthy people to experience benign fasciculations. Common areas of fasciculations are eyelids and thumbs.

More serious causes of fasciculations may be motor neuron disease, or denervation due to radiculopathy which are usually accompanied by weakness and atrophy of the affected muscle group. These pathological fasciculations generally tend to occur randomly, whereas benign fasciculations tend to occur repetitively at the same sight. As with cramping, it is suggested that fasciculations be evaluated by a professional to determine whether or not they are benign.

# **DYNAMIC STRETCHES**



**Yoga Twist**

Lay on back with arms straight out to the side, legs straight, one ankle over the other. Twist at the hips gently moving side to side. Do not force range of motion

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**Side Lying Trunk Twist**

Start on side, arms outreached, hips and knees flexed to a 90 degree angle. Reach back and across the body with the top arm until you get a stretch in the middle and lower portion of the back. "down" knee should not come off the ground

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
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15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



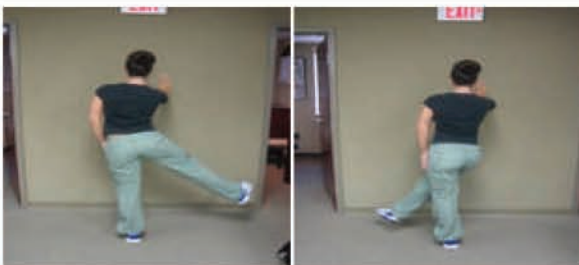
**Anterior-Posterior Leg Swings**

Holding onto an immovable object, rhythmically swing thigh forward and backward, go further as you loosen up. Maintain good posture, chest out, shoulders back, and eyes looking straight ahead. Keep the movement around the hips.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**Side-to-Side Leg Swings**

Holding on to an immovable object, rhythmically swing the leg from side to side, go further as you loosen up. Maintain good posture; chest out, shoulders back, and eyes looking straight ahead. Keep the movement around the hips

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:





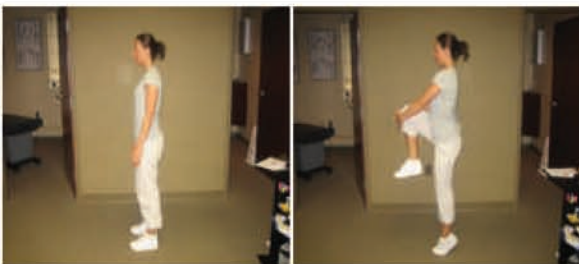
### Windmills

Set up with a wide stance, upright torso. Rotate and flex at the hips reaching your right arm to left foot. Rythmically transition, with rotation to ight side with left arm. Keep neutral spine, focus on hip flexion rather than lumbar flexion.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



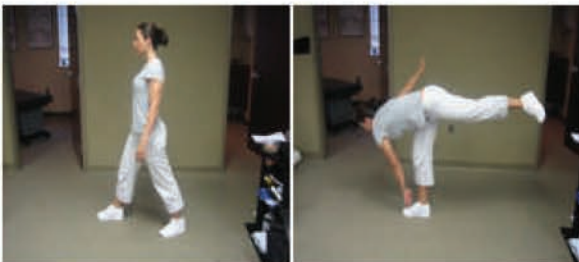
### High Knee Walks

Step forward and raise one knee. Actively pull knee up and in with both hands and come up on toes of opposite foot. Maintain good posture, avoid forward lean.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



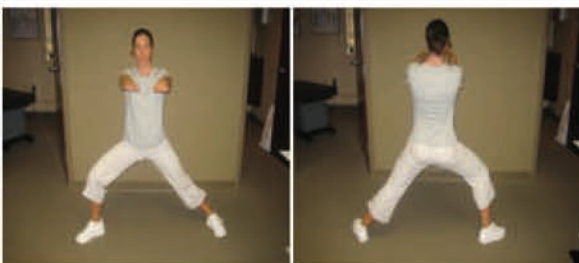
### Single Leg Hip Hinge

Step forward with weight on heel. With a slight knee bend and good posture, push butt back and lower torso to perform a toe touch as opposite leg swings back. Maintain good posture, keep eyes up.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



### Alternating Lateral Lunge

Step directly to side, land on heel and sink into a lateral (side) lunge. Kep chest up, weight on heel, and trailing leg straight. Toes of both feet should point forward with feet flat on floor. Maintain good posture.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



### Running Butt Kicks

Kick heel to butt by firing hamstrings. Make sure that the heel comes up on the standing leg.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



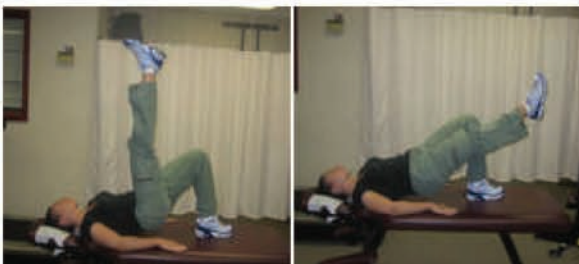
### High Knee Skips

Skip with exaggerated arms swinging; get knees high. Come up on toes with standing leg.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



### Supine Leg Whips

Lay on your back and push your hips up by activating your glutes. With hips up, raise one leg straight up. Lower the leg directly to the side, then "whip" it back up to starting position.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



### Warrior Lunge Hip Flexor Stretch

Assume a lunge position and reach overhead. Torso is upright and with no hyperextension at the lumbar spine. Stretch is felt on the front of the trailing legs hip. Stretch can be increased by rotating toward the front leg.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:





**Overhead Broomstick Rotation**

Hold broom stick shoulder width apart and reach back over your head. Go as far as you can in a pain free range of motion.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31



**Toy Soldier**

With opposite arm and opposite leg, walk forward making sure to kick the leg high enough to get a stretch

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

# STATIC STRETCHES



Notes:

### Warrior Stretch With Twist

Keep back straight. Lunge forward, twist and reach overhead. Keep a neutral spine.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



Notes:

### Standing Hamstring Stretch

Bend forward at the hip (Hip Hinge) without bending at the knees. Be sure not to round the back as depicted in the second picture.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



Notes:

### Hip Lunge

Keeping neutral spine lunge with back knee on floor. Keep torso upright and focus on stretching back leg.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



Notes:

### Prone ITB/TFL Stretch

Begin in a push up position. Bend one knee and bring instep underneath toward the opposite hip. Hips remain level, knee is at the line of the body. Lower by using bodyweight to increase the stretch. Keep back flat. Do not do with knee patients.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



Notes:

### Quad Stretch

Keep neutral spine  
Pull from top of foot to glute

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1 2 3 4 5 6 7  
8 9 10 11 12 13 14  
15 16 17 18 19 20 21  
22 23 24 25 26 27 28  
29 30 31



Notes:



### Abductor Stretch

Keeping a neutral spine place feet wider than shoulder width and lunge to one side

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1 2 3 4 5 6 7  
8 9 10 11 12 13 14  
15 16 17 18 19 20 21  
22 23 24 25 26 27 28  
29 30 31



Notes:

### Mid Back Stretch

Hold stable surface with 1 arm  
Hip hinge and lean back  
Do not round low back

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1 2 3 4 5 6 7  
8 9 10 11 12 13 14  
15 16 17 18 19 20 21  
22 23 24 25 26 27 28  
29 30 31



Notes:

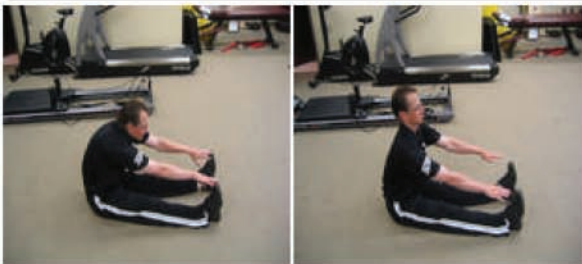


### Posterior Capsule Stretch

On your side with arm out so that shoulder is aligned with elbow bring forearm up to a 90 degree angle. With opposite arm push wrist down to floor. Lean upper body toward floor until stretch is felt.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1 2 3 4 5 6 7  
8 9 10 11 12 13 14  
15 16 17 18 19 20 21  
22 23 24 25 26 27 28  
29 30 31



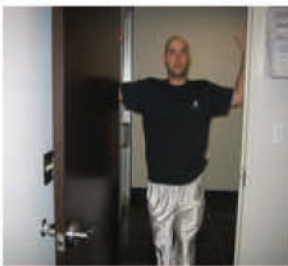
**Seated Hamstring Stretch**

Without bending at the knees, lean forward and try to touch your toes. Be sure not to round at the back as depicted in the first picture.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31



**Pec Door Stretch**

Grab hold of each side of the door frame  
Take a split stance position and lean forward to stretch the chest muscles. Placing the hands higher or lower will vary the stretch

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

## CHAPTER 10

1. Compared with static stretching, dynamic stretching actually reduces injury rates and improves certain aspects of performance.
  - A. True
  - B. False
2. Static stretching may relax you to a point of impairing concentration and mellowing you out.
  - A. True
  - B. False
3. Static stretching reduces elasticity and contractibility of the muscles and impairs reaction time, balance and coordination.
  - A. True
  - B. False
4. In most cases static stretching should be done \_\_\_ to exercise.
  - A. Prior
  - B. During
  - C. After
  - D. All of the above
5. A muscle should never be stretched while in full contraction
  - A. True
  - B. False
6. Proper Flexibility guarantees you will not be injured?
  - A. True
  - B. False
7. Low water intake can be related to?
  - A. Cramping
  - B. Fatigue
  - C. Light head feeling
  - D. All of the above
8. When performing Toy Soldiers, the most important thing is to kick up one foot and touch your hands even if your back is flex.
  - A. True
  - B. False

9. During the hamstring stretch the goal is to flex your back and touch your toes.
- A. True
  - B. False
10. At the start of the post capsule stretch, the forearm should be at a\_\_\_ with the floor
- A. 90 degree angle
  - B. 30 degree angle
  - C. 120 degree angle
  - D. None of the above

# CHAPTER 11

## The Core



The core is where most of the body's power is derived. It provides the foundation for all movements of the arms and legs. The core must be strong, have dynamic flexibility, and function synergistically in its movements in order to achieve maximum performance. Motion of the human body is not isolated to one muscle or tissue moving in one specific direction. It is a complex event involving agonist and antagonist structures that work together to create changes in position and stabilizes the body in all three directional planes of motion. Regardless the type of sport it is essential to have core strength and trunk stability to maximize performance and prevent injury, especially in active daily living.

The foundation of the core consists of more than just the abdominal muscles. It includes muscle attachments deep within the torso, from the pelvis up to the neck and shoulders. Abdominal muscles work together to transmit a compressive force and act to increase intra-abdominal pressure that stabilizes the lumbar spine. They can work individually to perform trunk rotation, while the internal and external obliques on the same side can work synergistically to laterally flex the spine. The muscles of the core include the following structures:

**External Obliques** – Abdominal muscles that attaches at the lower ribs, pelvis, and abdominal fascia.

**Internal Obliques** – Abdominal muscles that attaches at the lower ribs, rectus sheath, pelvis and thoracolumbar fascia.

**Transversus Abdominis** – Abdominal muscles that attaches at the lower ribs, pelvis, and thoracolumbar fascia, and rectus sheath.

**Rectus Abdominis** – Abdominal muscle that attaches at the fifth through seventh ribs, the lower sternum and the front of the pubic bone. This muscle flexes the spine, compresses the internal organs of the abdomen, and transmits forces laterally from the obliques. It is a common fallacy that the upper and lower rectus are isolated.

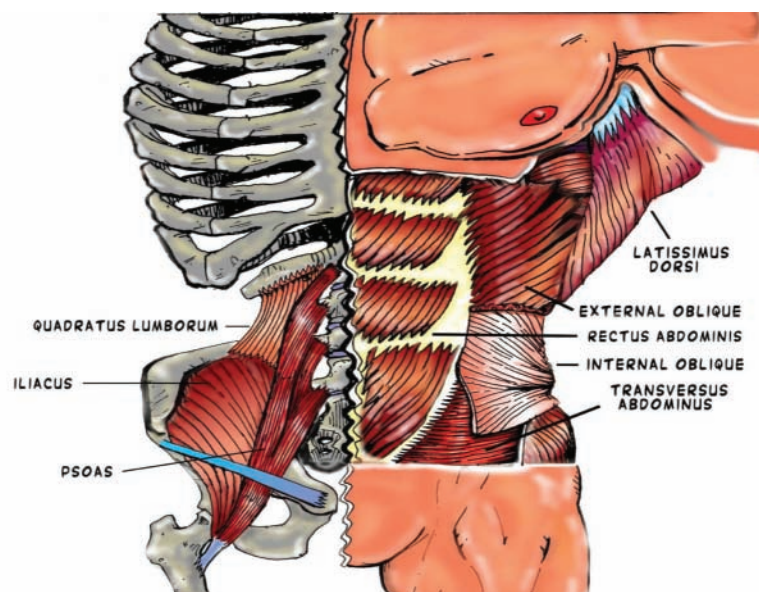
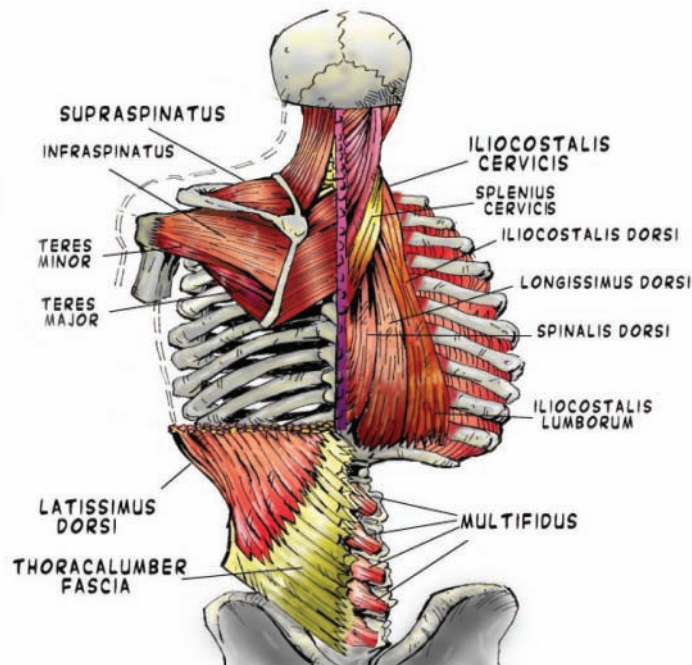
**Erector Spinae** – helps to counterbalance all the forces involved in spinal flexion. They begin as the sacrospinalis tendon which attaches at the sacrum and ilium. This tendon gives rise to different muscles that run up the spine and obliquely to attach at lateral parts of the vertebrae and ribs. In the cervical region, these muscles attach at the base of the skull.

**Quadratus Lumborum** – Attaches at the 12th rib and the upper 4 lumbar vertebrae and the pelvis. It stabilizes the lumbar spine in all planes of motion while stabilizing the 12th rib. It attaches to the diaphragm during respiration and laterally flexes the trunk.

**Latissimus Dorsi** – It is the largest spinal stabilizer attaching from the thoracolumbar fascia to the lumbar vertebrae, sacrum and pelvis, traveling superiorly to the humerus. It assists in lumbar extension and stabilization, and also performs pulling motions through the arms.

**Thoracolumbar Fascia** – Connects the latissimus dorsi, gluteal muscles, internal obliques and transverse abdominis, supplies tensile support to the lumbar spine, and is used for load transfer throughout the lumbar and thoracic regions.

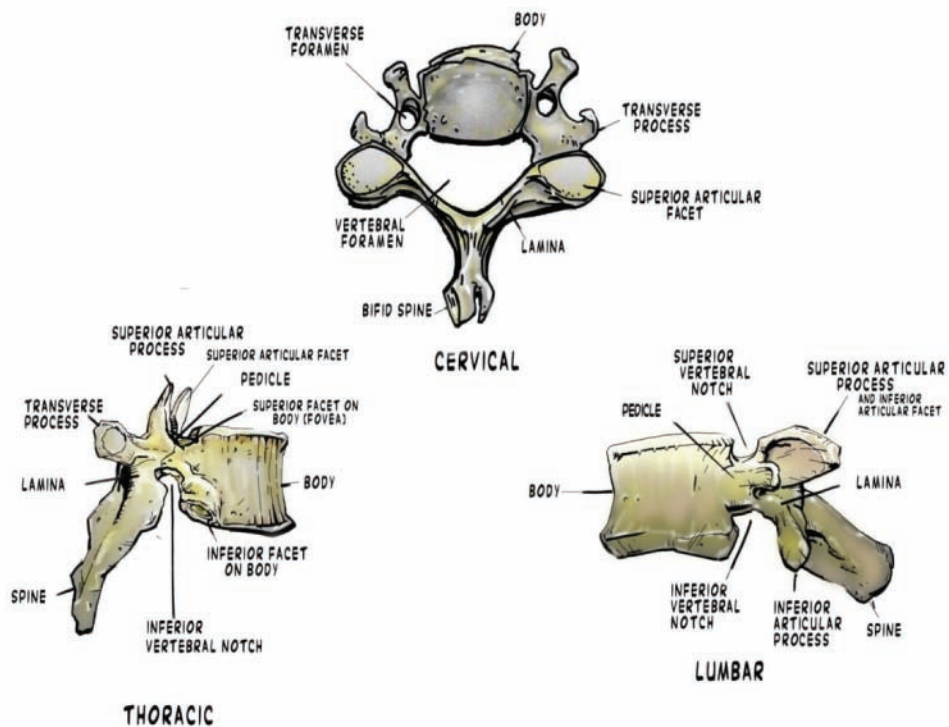
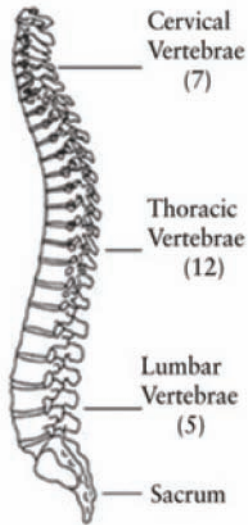
**Abdominal Fascia** – Connects to the obliques, rectus abdominis, and pectoralis major. Fascia connections that cross the midline transmit forces to the muscles opposite side. Muscles of the Spine



**Multifidus** – Deep spinal muscles that run segmental from the cervical spine (C2) to the sacrum. They allow for extension, and, to a lesser degree, rotation and lateral flexion providing stability of joints at individual discs of the spine.

**Interspinales, Intertransversarii, Rotatores** – Deep structures that directly attach to the spinal column. These are very important for rotational motion and lateral stability.

**The Spine and its Vertebrae**



## **Functional Core Routine**

The common myth is that training the core simply involves sit ups and back extensions. An efficient core routine consists of multiplanar movements or training in all planes of motion. As the body moves its center of gravity changes, and forces exerted by and on the body's tissues are constantly changing. Dynamic stabilization must be included to increase proprioception and stability in the trunk and rest of the body. This allows the parts of the body to react efficiently to external forces and stresses, such as gravity, changes in terrain, carrying loads, and internal forces exerted by other muscles.

A proper functional core routine consists of dynamic movements, challenges the center of gravity and isometric exercises. To completely train the core, you must also include dynamic stabilization, isometric and proprioceptive movements not just for the mid section but the entire trunk. Medicine balls, balance boards, foam rollers and physio balls are great tools for core training and should be integrated into every program. It is a fact that training on the physio ball (challenged environment) is superior to traditional floor exercises. As a person ages, balance and stability become compromised. If balance and stability are not addressed they will consistently degrade.

Dynamic stability is best achieved through training in functionally practical positions that mimic activities or movements in a particular sport or daily activity. With this in mind, an observation has been drawn remarking most core training is done while sitting or lying down limiting pelvic movement which has little functional value.

A weak core contributes to poor stability and inhibits proper limb movements causing muscle imbalances in the kinetic chain. This is why falls are common in the geriatric population. Many back and hip injuries are related to weak core muscles. There are many small muscles in the core that the general population knows little about or addresses during exercise. MRI images show atrophy in these small muscles in most spinal injuries. These little muscles need to be trained in order to maintain a healthy spine. Without stability, even the strongest person can not effectively propel a force into the environment.

The goal of functional core training is to develop the core as a system of efficient automatic responses to work as a stable base from which to generate optimal force and motion. A key term to know is proprioception, the sense of the relative position of neighboring parts of the body. Dynamic Stabilization is another key term to be familiar with and this relates to strengthening of the core muscle stabilizers of the spine (transverses, abdominis, and multifidus) while keeping the client in a 'Neutral Spine' position.

Core Stability Testing\* to evaluate your client's core strength is crucial when creating a solid exercise program. Later in the chapter we will show exercises which are good to incorporate into your clients evaluation as well as into the routine you set for them. To train the core effectively you must establish motor control, mobility, and stability as well as developing core strength and increasing its power.

## Core Progression\*

It is important to understand progression when training your client. Progression is about challenging the person further once they master a particular movement, do not memorize programs understand them. Correct any postural distortions, faulty motor patterns or balance issues first. Start with basic stability exercises and stretching on the floor. Focus on holding a neutral spine; quadruped arm raise, knee planks, upper back only cat camels and glute bridging are great exercises to start with. Once the client proves they can maintain a neutral spine with these exercises in a static position add some perturbations. Don't change the exercises so fast just make them harder. Here are some basic progressions broken down by level:

1.
  - 1) Quadruped arm raise
  - 2) quadruped leg raise
  - 3) quadruped arm and leg raise
  - 4) quadruped arm raise with knees on a ½ foam roller
  - 5) quadruped leg raise with knees on a ½ foam roller.
  - 6) quadruped leg raise with knees on a ½ foam roller and hands on dyna disc.
  - 7) knee planks
  - 8) knee plank with foam roller
  - 9) full plank
  - 10) plank with leg raise
  - 11) plank on roller
  - 12) plank on ball with airex pad under feet
  
2.
  - 1) Upper back only cat camels
  - 2) low back only cat camel
  - 3) cat camel
  - 4) cat camel with eyes closed
  - 5) cat camel on half foam roller.
  
3.
  - 1) Static glute bridge
  - 2) two leg glute bridge
  - 3) two leg glute bridge with band around knees
  - 4) two leg glute bridges with feet on airex pad
  - 5) 1 leg glute bridge
  - 6) 1 leg glute bridge on dyna disc.

Once your client shows proficiency performing basic floor movements you should incorporate some basic standing balance exercises and spend less time on the floor as they improve. Here are some basic progressions broken down by level: 1) one leg stand holding neutral spine 2) one leg stand holding neutral spine with pertubations 3) one leg stand with eyes closed 4) one leg stand on airex pad 5) one leg stand with eyes closed on airex pad

This exercise can easily be transformed into a strength exercise. 1) one leg standing medicine ball chest pass 2) one leg standing chest pass on balance board 3) one leg standing chest pass on dyna disc

You can change this into a power exercise for core and chest by 1) explosive chest pass on two feet 2) squat to explosive chest pass 3) lunge to explosive chest pass 4) plyometric jump with explosive chest pass

The hip hinge is the most under used exercise in the gym. This movement is the foundation for more movements than you can think of. You cannot do a proper squat without first learning the hip hinge. 1) hip hinge with bent knees 2) hip hinge with stiff legs 3) bent knee hip hinge without pole 4) hip hinge with stiff leg without pole 5) one leg hip hinge with pole 6) One leg hip hinge without pole

This exercise can easily be transformed into a strength exercise. 1) dumbbell squat 2) dumbbell front squat 3) back squat 4) one leg squat 5) one leg squat on airex pad. You can change this into a power exercise 1) low intensity jump tuck 2) explosive jump tuck 3) jump tuck with weight

The major difference between power and strength is the speed of the movement, rep range and recovery time needed before the next set. It's not always suggested to do power movements with balance devices because the idea of power training is to force the nervous system to fire as many muscles fibers as possible. This is accomplished by trying as hard as you can to perform a movement. Using balance devices will not allow you to use as much weight and creates a greater risk of injury and will not allow you to transmit the force you need onto the floor or playing field effectively.

In the beginning stages choose movements that lead up to the weight training exercises you have planned for the future, remember the client must first control the movement with body weight then add resistance. You have to be creative when progressing seems too hard but the current exercise is too easy. For example if someone can do a one leg stand on the pad easily but can't do it with their eyes closed on the floor do something in between like adding perturbations on the pad or closing one eye on the floor. It's not incorrect to do two legged exercises with challenged environments before single leg movements in unchallenged environments. Adding resistance with two feet before single leg movements is more appropriate for certain clients. Partial movements are great for exercises that clients can't fully perform. In most cases don't load up with weights; the goal is to increase the range of motion first. There is more than one right way to design a program.

Educate your client on basics, for instance, how they sit every day can cause back pain. Mention how their other daily activities done wrong can result in injury or hindered performance. Explain pelvic tilting and how it affects muscle activation in the core and relates to movements.

The way you progress each person is completely dependent on the client's goals and needs. You are not going to plan a program that leads up to Olympic lifting for the middle age woman that only wants to work out one or two days per week and whose only interest is to maintain weight and stay healthy. If the goal is for a brand new inexperienced client that wants to become an athlete the basic stages of progression are: Introduction to basic movements focused on muscle activation and motor control. Basic strength exercises related to their sport. Intense strength training with basic plyometrics then sport specific explosive lifting with complex plyometrics.



If the goal is for a brand new inexperienced client that wants to lose a few pounds and has some injuries the progression should be similar to the following. An Introduction to basic movements focused on muscle activation and motor control. Then basic strength exercises related to their daily activities and weaknesses. Once they have shown objective improvements incorporate complex exercises related to their daily activities then light plyometrics with other simple explosive exercises. Your goal should be to get clients to play a sport for fun and extra exercise.

Determining repetitions is completely dependent on what you are looking to accomplish. In early rehab stages it's recommend between 12 and 20 reps with a tempo around 4/0/1 - 5/0/2 either every day or every other day depending on what exercise. Most people can't perform that many reps so stop them whenever their form fails and just do more sets so in the end the rep total ends up the same. Early strength stage 10-12 reps around a 3/0/1 - 4/0/1 tempo is usually good. Sometimes I purposely do less reps and more sets so that the client is forced to get into the correct starting posture more often during the routine. Once they are comfortable then be ready to really implement intense strength training which is between 8-12 reps with a 3/0/1 tempo. This stage includes super sets, compound sets and difficult full body exercises. For power and plyometrics the movements must be done in an explosive fashion, tempo is about 1/0/explode.

This is just a very basic guideline to help you understand how to think. It is by no means the only way and in fact we encourage learning from various sources. This will allow you to take what you think is best from each resource and apply it to a situation a client may have. Tempos and rest periods are important and often under rated so pay attention to them and change them when needed. Program design is a very complex and can be difficult.

## **Core Training for Cyclists and Runners\***

### **Cycling**

Most cyclists focus on their hamstrings, quadriceps, gluteal muscles, and forget about the importance of core stability.

Consider how many hours the cyclist spends bent over in a flexed position on the aero bars with no rotational or side bending motions. A strong core is necessary to counter-balance these forces and minimize injury. Proper core strength will allow the athlete to generate maximum power and sustain a higher level of intensity for longer periods. Minor changes in brake position positively or negatively affect core stability. If the brake handle position is too low, the cyclist is forced to reach far forward with their forearms. This reaching position forces the cyclist to raise their head forcing the pelvic girdle posteriorly. This position can cause a restriction in several key muscles in the core reducing performance. The ideal position for the forearms is to have the elbows bent and the forearms flattened out. In this position, the cyclist's head drops into a more comfortable aerodynamic position, and the pelvis tilts forward. In this position, the cyclist is able to use all the core muscles with improved efficiency.

## **Running**

A shortened Rectus Abdominis will hinder an athlete's performance during running. Although opinions about the 'ideal running form' vary greatly, most authorities will agree that the less energy that is expended, the more effective and efficient the running style will be. Here are running recommendations obtained from Runners World Online are:

- Run upright. Your back should be straight, roughly at a 90-degree angle to the ground.
- Look straight ahead. Your eyes should be focused straight down the road on a point moving about 10m in front of you. This helps to keep you in a straight line.
- Swing your arms naturally. The angle at the elbow between your upper and lower arms should be about 90 degrees. Your hands should be loosely cupped, about belly level.
- A shortened rectus abdominis will pull the runners posture forward. This causes a braking action that reduces running economy.

As the rectus is shortened it pulls the chest forward allowing gravity to pull the head down. In order to look straight ahead as instructed, the athlete wastes a considerable amount of force in trying to overcome the contracted rectus abdominis.

As the shoulders move forward a shortened rectus abdominis causes the arms to rotate internally. This makes keeping your arms relaxed at the recommended 90-degree angle much more difficult and reducing running economy.

When performing a biomechanical analysis, it is very common to see numerous imbalances of which the athlete is completely unaware. By video taping an athlete during their activity, the practitioner can show and explain what is happening, and then correction can be implemented.

When analyzing a runner some of the most common biomechanical faults are:

**Over-pronation** - In lower extremities (rolling in as the arches collapse) - This can cause a series of biomechanical imbalances from the foot up to the cervical spine.

**Excessive hip adduction** – Due to tight hip adductors and can cause increased load in the lateral tissues, such as the iliotibial band, tensor fascia lata, and gluteus medius.

**Lack of trunk rotation** – Restrictions in trunk rotators or shoulder extensors. This can cause overload in the hip musculature, spinal joints, and other trunk rotators.

**Lack of hip extension** – Caused by tight hip flexors restricting extension, and weak gluteal muscles. This causes the extensors and rotators of the lumbar spine to become overloaded in order to compensate for the lack of hip extension.



**Lack of shoulder extension** – Caused by restrictions in anterior shoulder muscles or poor trunk rotation

### **Pelvic Tilting**

**Anterior pelvic tilt** – Position of pelvis is determined by the ASIS, which is pointed anterior (forward). This is usually associated with hyperlordosis, or hyperextension, of the lumbar spine. The glutes usually stick out.

**Posterior Pelvic tilt** – Position of pelvis is determined by the ASIS, which is shifted posteriorly (back). This is usually associated with hypolordosis, or flexion of the lumbar spine. Belt buckle is up towards belly button.

**Neutral spine** – midway balanced point of the spine that requires the least amount of muscular contractions

\*represents headers with more detailed descriptions in the following sections of this chapter.

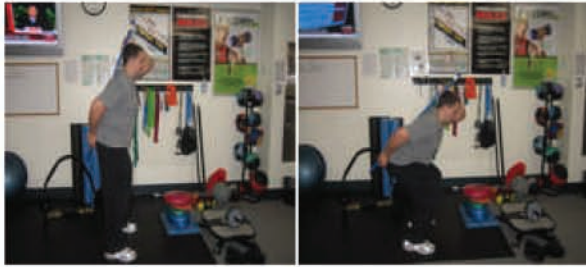
# **CORE STABILITY TESTING**

## Core Stability Testing – Hip Hinge



- Stand with feet shoulder width apart and knees slightly bent
- Hold a pole from your head past your tail bone
- Bend from the hips without letting the pole separate from the body
- If pole moves from body you are going too far, Stay in a safe range of motion
- Look for rounding the lower back: tight hamstrings or psoas
- Going up on toes: poor core stability and poor motor control
- Rounding upper back: tight pecs and lack of motor control throughout spine
- Pain: can be a disc injury

This movement is so important because it promotes a neutral spine and spares the lower back during movements such as dead lifting, squatting and stiff leg exercises. It should be implemented into everyone's daily activities because, most back injuries are result of repetitive stress caused by improper sitting and bending methods. This exercise teaches how to stabilize the back while generating power from the hips. If the client has trouble just do a partial range and bend knees more. This is used as a test but it is also a great exercise.



**Bent knee hip hinge**

Pin a broomstick from the back of your head to tailbone. keep knees bent and core braced. Perform a squat without letting the broomstick come off of your spine. The broomstick insures a neutral spine.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**Hip Hinge**

A: Correct: Keep spine straight by hinging at the hips.

B: Incorrect: Spine bends forward putting low back in a harmful position. Hold pole against the back of your head and tail bone. Once the pole breaks from the body clients not using their hips. Client may bend knees to get lower. Master this before doing any weights. This is not so much a test its just a way for you to see how poor bending mechanics are.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes: A

B



**Single leg hip hinge with pole**

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**Squat - Dumbbell**

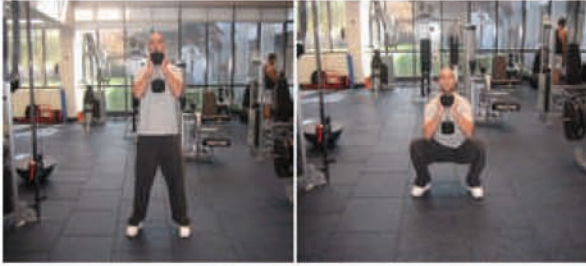
Standing in readiness position with feet shoulder width apart. Hands down in front holding weights between legs. Slowly lower body down into a squat position keeping head and chest up maintaining a neutral spine and braced core. Do not allow knees to buckle inward. Keep body centered over the ankles to raise up to the starting position. Repeat. You can hold a dumbbell in each hand if thats better. To improve leg strength and core recruitment

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:





**DB Front Squat**

Hold DB in front of your chin  
perform squat making sure back is flat and chest is out

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31



**Barbell Squat**

Center barbell behind the neck and across the shoulders (traps) w/hands approx. half way between weights and shoulders. Feet approx. shoulder width pointing slightly outward. Lower yourself under control by bending knees and hips. Keep neutral spine, braced core and eyes fixed straight ahead. Do not bounce at the bottom of the movement.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31



**One leg Squat**

Place 1 leg on a bench or ball  
The front foot should be place shoulder width and far out enough to allow a comfortable squat  
Keep a neutral spine, braced core and go down as far as comfortable.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

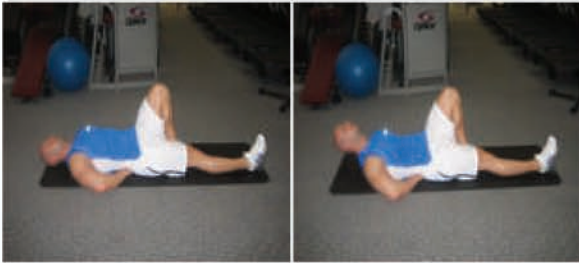
Notes:

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

## Core Stability Testing - Flexor Endurance



- Have the patient sit up 3-4 inches
- Time how long patient can stay up.
- 50 to 60 seconds is an average time for this test



**McGill Crunch**

Start flat on back with hands interlocked under lumbar spine and one leg bent. Keep spine neutral and brace entire time. Look straight up at ceiling and crunch, shoulder blades should barely leave the floor. Lifting elbows off floor engages lats and makes more difficult.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:



**Crunch on dyna disc**

Place dyna disc under low back. The closer to the tail bone the more difficult. Start with back off the floor, crunch up and return to start. Crunch by shifting the air not by flexing your spine. Don't come too far up. Avoid touching the floor.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:



**Pike**

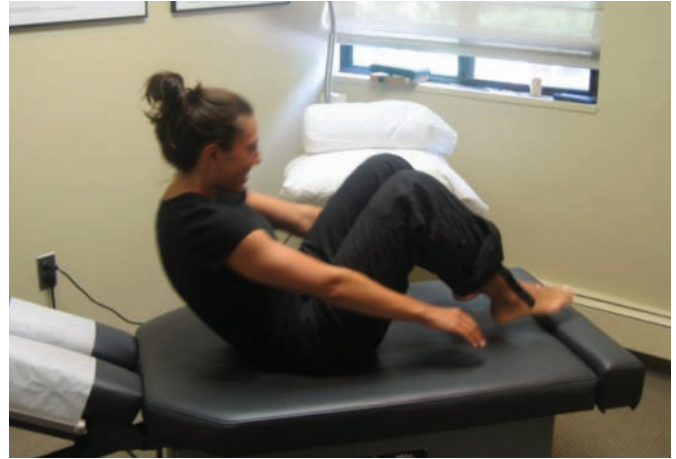
Place toes on ball and assume a push up position. Keeping a neutral spine pull the ball in while elevating your glutes in the air. Bring toes in towards chest. Do not round your back.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:

## Core Stability Testing – Trunk Curl



- Have client lay supine with knees bent
- Ask client to sit up
- Check to see if they clear their scapula
- HELL elevation reveals compensation
- Check for abdominal yoking





**Abdominal Bracing Leg / Arm Extension**

Lying on back with feet in the air, knees bent to 90° and arms straight up in front.

Slowly straighten one leg out and raise the opposite arm over head to the floor.

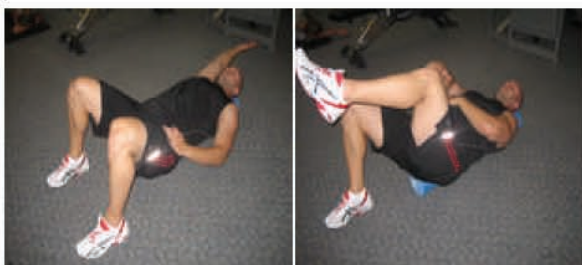
Maintain abdominal bracing throughout movement.

Return to starting position and repeat with opposite side.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**Dead Bug w/ Foam Roller**

on a foam roller touch opposite arm to leg concentrate on a neutral spine and dont let roller move

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**Ball Crunches**

Lying on gym ball with the ball under the small of the back (or slightly higher).

Gently cradle head in the hands (do not pull with arms). Brace abdominals and sit up towards a seated position, leading with the chest and keeping head neutral. Lower with control and repeat. Maintain the abdominal brace and neutral spine throughout the movement.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:

## Core Stability Testing - Side Plank Endurance Test



- Have patient perform a side bridge
- Test to see how long they can hold
- Pay attention to hip dropping
- This test will reveal core weakness
- 30 to 45 seconds is passing time for this test depending on sex and age.



**1/2 Side Bridge**

Lying on one side with knees bent keeping knees, hip and shoulder in line. Support upper body on elbow, placing elbow directly under shoulder. Raise hip up off floor, brace core and hold a neutral spine. Avoid rotating forward or backward.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

To strengthen the muscles of the core.

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**Side Bridge - Forearm**

Lying on side with legs out straight (feet staggered) keeping, hip and shoulder in line. Support upper body on forearm, placing elbow directly under shoulder. Raise hip up off floor brace core maintain a neutral spine and hold. Avoid rotating forward or backward.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

To improve core strength.

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**Side Bridge / Rot.**

Start in a push up position with elbows straight and body in line. Keeping body tight rotate up onto one arm into a side bridge position, turning as a unit. Hold, return to start position and rotate opposite direction. Maintain abdominal brace and neutral spinal alignment throughout movement.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:

## Core Stability Testing – Plank Endurance Test



- Lie face down on mat resting on the forearms, palms flat on the floor.
- Push off the floor, raising up onto toes and resting on the elbows. Make sure elbows are underneath shoulders.
- Look for lumbar hyperextension = weak rectus abdominus muscle
- Inability to extend hip = tight psoas muscle
- Shoulder shrugging = weak trunk and poor shoulder stability
- Kyphosis = tight pectorals and lack of T3/4 extension
- Shoulder pain can be associated with this test it also indicates weak shoulder muscles
- Passing time is about 45-60 sec depending on sex and age.
- This exercise should be incorporated into your clients routine





Notes:

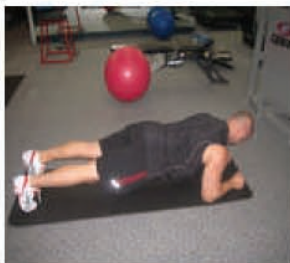
**Half Front Plank - Knees**

Support body in a half plank position with forearms shoulder width apart and knees together. Keep a straight line through the knee, hip and shoulder. Maintain abdominal brace with a neutral spine.

To strengthen core musculature.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31



Notes:

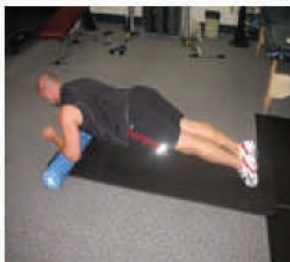
**Plank**

On elbows and toes keep spine neutral hold trunk off floor

Do not let Low back drop, Shoulders shrug  
Upper back round.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31



Notes:

**Foam Roller Plank**

Place elbows on foam roller and toes on floor  
Maintain a neutral spine and do not move roller

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31



Notes:

**Full Upper Body Plank on Ball**

Start from a kneeling 'prayer' position with forearms on ball. Push upper body up into a full push-up position supported with forearms on ball. Hold plank position maintaining abdominal brace and neutral spine.

To improve core strength and proprioception.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

## Core Stability Testing - Crossover



- Push up position with legs about shoulder width apart. Keeping back neutral touch one hand to another and return to start position without shifting body. Immediately repeat with opposite hand and continue to alternate.
- Can't keep neutral spine = weak core
- Trapezius hiking = overactive traps
- Scapular winging = weak serratus anterior
- Hip rotation = weak trunk and glutes
- This is a good exercise to incorporate into your clients routine as well



**Crossover on knees**

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:



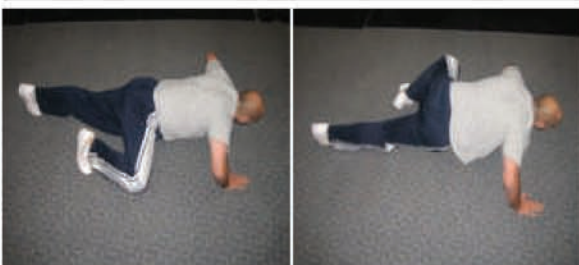
**Crossovers**

This tests trunk stability  
Start in a push up position. Legs spread wider than shoulder width. With back straight, touch one hand to another and return to starting position without shifting your body. Immediately do the same thing with the other hand and continue to alternate.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:



**Ladder crawl**

Get into pushup position keeping core tight pretend to crawl down the ladder or for more resistance, up the ladder

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:

## Core Stability Testing – Foam Roller Supine Extremity Raise



- Place roller along spine
- Plant both feet on floor with knees bent
- Pick up one foot and stabilize with the other
- Knee or trunk shaking = weak glutes, core, calf and or lack of proprioception
- Can't hold position: All around weakness/imbalance





**Abdominal Bracing / Leg Drag**

Lying on back with knees bent and feet flat on floor.

Slowly straighten one leg out along floor while maintaining an abdominal brace and neutral spine.

Slide leg up to starting position and alternate.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:



**Abdominal Bracing Leg / Arm Extension**

Lying on back with feet in the air, knees bent to 90° and arms straight up in front.

Slowly straighten one leg out and raise the opposite arm over head to the floor.

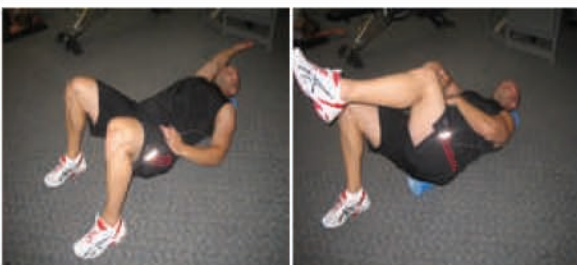
Maintain abdominal bracing throughout movement.

Return to starting position and repeat with opposite side.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:



**Dead Bug w/ Foam Roller**

on a foam roller touch opposite arm to leg concentrate on a neutral spine and dont let roller move

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:

# **TRAINING THE CORE**

## Unilateral Knee Lift



- Lie on foam roller with feet flat on floor bracing abdominals and keeping a neutral spine.
- Place arms on chest or make it easier and place alongside roller. Raise one knee toward chest.
- Maintain a 90 degree angle between knee and hip.
- Lower leg to floor.
- Repeat with opposite side.

## Dyna Disc Crunch



- Place dyna disc under low back. The closer to the tail bone the harder it is.
- Start with back off the floor and arms straight out in front of body.
- Crunch up while shifting hips downward keeping a neutral spine and return to start.
- Avoid touching the floor.

## Overhead Medicine Ball Abdominal Bracing



- Lying on foam roller with feet flat on the floor.
- Hold medicine ball with both hands over the chest.
- Keeping arms straight, extend ball behind head and return to starting position.
- Keep abdominals tight and neutral spine through the entire movement.



## Supine Cross Bridge on Foam Roller



- Lie on foam roller with feet on the floor and holding medicine ball.
- With arms straight and keeping braced abdominals and neutral spine move med ball from side to side.
- Return and repeat.

## Abdominal Crunch



- Lying on your back, with the knees bent, and your arms folded across your chest or hands behind your head, slowly roll your shoulders away from the floor until a strong contraction is felt in the abdominal.
- Return to the starting position under control and repeat for the prescribed number of repetitions.
- Remember to maintain a neutral spine, exhale on the exertion, and avoid poking the chin.

## Cable Pull Through



- Start in a half squat position with a rope handle attached to a cable between your legs.
- Stand up and as you stand pull the rope through your legs and lock out at the hips while squeezing your glutes.
- Strengthening the glutes will help stabilize the low back and spare the spine.

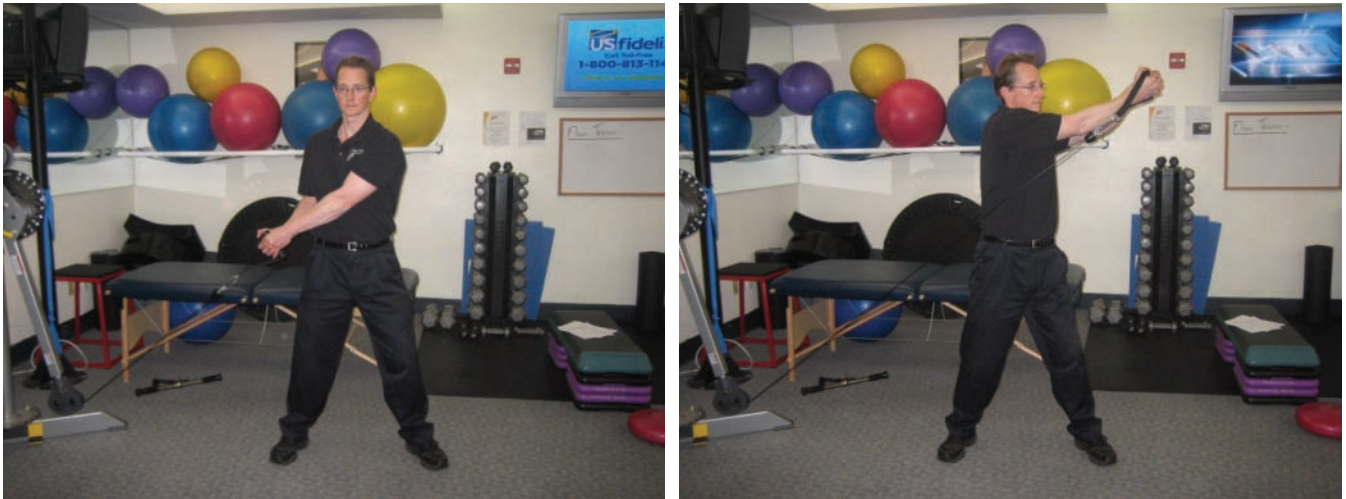


## Downward Cable Chop



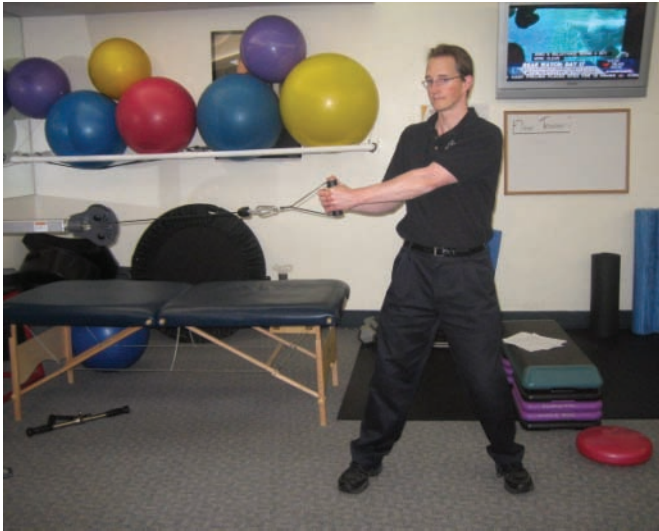
- Grasp handle of cable with both hands, keeping arms straight, but elbows not locked out.
- Keep abdominals tight, spine neutral and shoulders down, twist from the hips keeping a neutral spine. Pull cable in a downward diagonal motion keeping the shoulder in line with the hip.

## Upward Chop



- Keeping abdominals tight and neutral spine.
- Twist from the hips while pulling arms upward.
- Repeat

## Transverse Cable Chops



- Keeping abdominals tight and neutral spine.
- Hold cable in both hands with arms out in front of body.
- Twist from your hips while pulling through with your arms.
- Repeat

## Sit up To Throw



- Lie with lower back resting on gym ball, keeping shoulder blades off the ball and maintaining a neutral spine.
- Throw medicine ball to partner bracing core the entire time. The movement is small do not round the back.

## Step Back Medicine Ball Twists



- Stand with med ball held out straight out in front of you.
- Take step back while twisting torso to the opposite side of the drop back leg. Keep spine neutral and abdominals braced.
- Return and repeat.



## Side Step Chop



- Hold a medicine ball in front of body.
- Step to side and raise ball diagonally overhead.
- Bring ball down and to opposite side, keeping abdominals tight and spine neutral.

## Pike on Ball



- Get in a pushup position, then rest the tops of your feet on a Swiss ball.
- Keep your legs as straight as possible, bend your hips and try to pull your feet toward your chest so that the ball rolls forward.
- Hold at the top for three to four seconds, then slowly roll back to the starting position.
- Continue rolling the ball backward (letting it move up your legs) until your body forms a straight line. That's one rep.

## The Jacknife



- Start in push up position with your feet on the Swiss ball and hands on floor below shoulders.
- Hold spine in perfect alignment. While maintaining neutral spine throughout the movement, draw knees towards chest.
- Hold and then return to start position.
- The further the ball is away from you the harder the exercise. Repeat as many times as you can hold perfect alignment. Do not compromise technique for reps.



## Bosu Ball Spike



- Maintain balance while standing on a Bosu ball.
- Hold a medicine ball overhead, keep abdominals tight and a neutral spine. Spike the ball on the floor to partner using the core.

# **PROGRESSIONS**

## **KEY**

Exercise Progression Key

Quadruped progression



**Arm Raises Quadruped**

On hands and knees, maintain abdominal brace and neutral spine.  
Slowly raise one arm out in front until parallel with floor, keeping rest of body stable.  
Lower arm to floor.

Notes:

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31



**Quadruped Single Leg Drag**

On hands and knees on the floor.  
Slowly straighten one leg out behind while sweeping toe across the floor.  
Keep neutral spine, chin tucked and maintain an abdominal brace throughout the movement.

To improve core recruitment and spinal stabilization.

Notes:

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31



**Cross Crawl Quadruped**

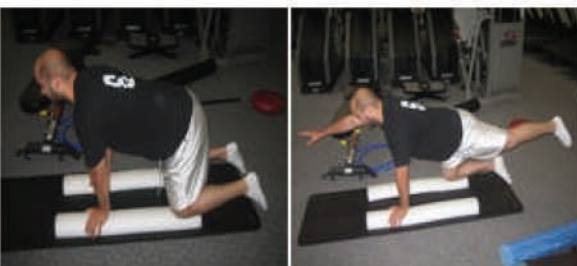
On hands and knees, maintain abdominal hollow and keep back flat.  
Slowly extend one leg behind while at the same time extending opposite arm out in front until parallel with floor.  
Keep trunk square and stable.  
Return arm and leg to floor and alternate.

To improve core strength and spinal stability.

Notes:

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31



**Half Roller Bird Dog**

Place 2 half rollers on the floor in a fashion that allows your hands and knees to be in the center reach with opposite arm and leg keeping neutral spine and braced core. Do not allow any hiking or extensor recruitment.

Notes:

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31



Notes:

**Half Front Plank - Knees**

Support body in a half plank position with forearms shoulder width apart and knees together. Keep a straight line through the knee, hip and shoulder. Maintain abdominal brace with a neutral spine.

To strengthen core and promote stability.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



Notes:

**Plank**

On elbows and toes keep spine neutral hold trunk off floor

Do not let Low back drop, Shoulders shrug  
Upper back round.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



Notes:

**Foam Roller Plank**

Place elbows on foam roller and toes on floor  
Maintain a neutral spine and do not move roller

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



Notes:



**Full Upper Body Plank on Ball**

Start from a kneeling 'prayer' position with forearms on ball. Push upper body up into a full push-up position supported with forearms on ball. Hold plank position maintaining abdominal brace and neutral spine.

To improve core strength and proprioception.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				





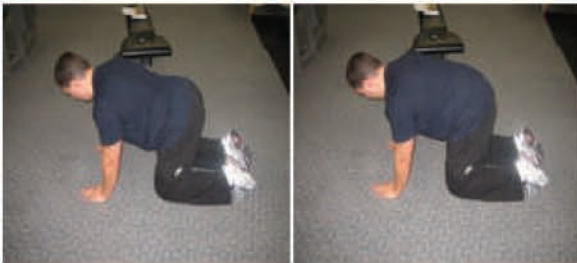
**Upper Back 'Cat'**

From a hands and knees position, raise forearms up onto a low stool. Let upper body drop down through arms as if to sink spine into the body. Spine should sink through the shoulder blades, not arch at the low back, keep it neutral. Relax into the position, breath and return to start.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**Low back cat/camel**

Perform a pelvic tilt in quadruped position. Limit upper back movement as much as possible, the movement needs to be lower lumbar/sacrum.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**Cat / Camel**

On hands and knees. Let stomach muscles relax and spine sag down. Suck stomach muscles up and in and arch spine up toward the ceiling like a 'mad cat'. Lower back down and repeat. Move within your pain free range of motion.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**Bridge**

Lie on back with knees bent and feet flat on the floor. Place arms 45° at sides with palms up. Neutral spine maintaining abdominal bracing, squeeze buttocks and slowly raise pelvis up off floor into a bridge position. Shoulder blades should remain on floor. Hold at end position, then lower and repeat. Start this exercise with no movement, just hold the second position.

To strengthen the Glute muscles and core stability.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**Bridge / Tubing**

Lie on back with knees bent and feet flat on the floor, with tubing or a belt around thighs. Place arms 45° at sides with palms up. Maintaining outward resistance into belt as well as maintaining abdominal hollowing, slowly raise pelvis up off floor into a bridge position. Shoulder blades should remain on floor. Hold at end position, then lower and repeat.

To strengthen the muscles of the core and Glute Max/Med

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**1 Leg supine Glute bridge**

Lay on back with one leg extended out and the other on the floor. Lift body off floor using glutes and return to start, don't arch the back. Maintain abdominal brace and neutral spine. Squeeze glutes the entire motion and don't arch. The Further you extend the static leg the harder it gets.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**Single leg dyna disk bridge**

Start on back, arms at sides, knees bent, feet flat on floor. Go only as high as your glutes will let you, don't arch the back. Lower yourself under control to a point just above ground and repeat. Maintain abdominal brace and neutral spine. Keep foot as steady as possible.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**One Leg Stand**

Stand on one leg, keeping knee soft and opposite leg bent up in front. Maintain abdominal brace and neutral spine. Try holding an object to start. Once you can do it free standing start moving the arms to challenge your center of gravity. Once you can do 1 min without tipping close your eyes. To improve single leg balance and proprioception.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**Rocker Board with Pertubations**

Standing on 2 legs on the rocker board have a partner push from side to side at the hips and shoulders. Push the person the direction the board rocks. To challenge core stability.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**One legged standing on foam mat**

Place one leg on foam mat and try to maintain balance. Brace the core and maintain a neutral spine. To improve single leg proprioception and balance.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:





**1 Leg Med Pass**

Stand on 1 leg. Keep abdominals tight and a neutral spine. Throw ball from chest height to partner. We find barefoot is best for most balance training.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**Wobble board med ball pass**

Stand on wobble board with both feet. Hold med ball in front of chest. Throw ball to partner, then catch, while maintaining balance, braced core and neutral spine. Repeat. Start with a rocker board first. To develop core strength.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**1 Leg wobble catch w med ball**

Stand on wobble board with 1 leg. Hold ball in front of chest and throw to partner, then catch, while maintaining balance. Repeat.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



# **CORRECTIVE EXERCISES FOR RUNNERS AND CYCLISTS**



**Cat/Camel**

Hands under shoulders, knees under hips. Lift head and chest and let stomach sink. Then round the back and bring head and hips together. Avoid bending elbows and moving body forward and back.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



**Sphinx**

Lie on your stomach propped up on your elbows. Inhale and round your middle back towards the ceiling. Exhale and imagine a string on top of your head elongating your spine. At the same time allow your chest to drop towards the floor. Keep your chin tucked in and neck straight.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



**Bird Dog**

On hands and knees maintain a neutral spine while extending the opposite arm and leg. Keep hips level and do not use the lower back or hike the shoulder.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



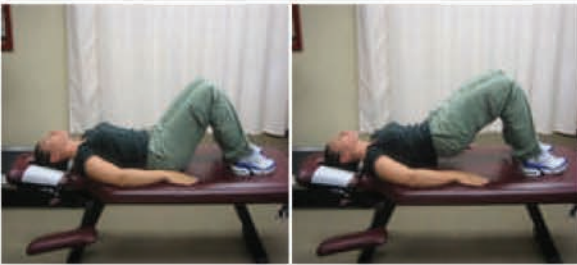
**Warrior Lunge Hip Flexor Stretch**

Assume a lunge position and reach overhead. Torso is upright and with no hyperextension at the lumbar spine. Stretch is felt on the front of the trailing legs hip. Stretch can be increased by rotating toward the front leg.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



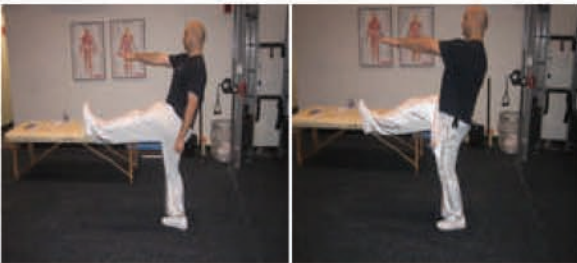
**Supine Bridge**

Start on back, arms at side, knees bent, feet flat on the floor. Squeeze butt throughout the movement going up as high as the glutes take you. Lower under control to a point just above ground, then repeat.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31



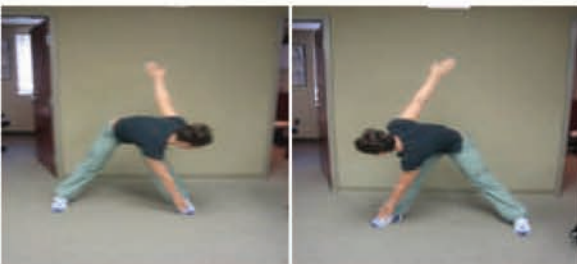
**Toy Soldier**

With opposite arm and opposite leg, walk forward making sure to kick the leg high enough to get a stretch

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31



**Windmills**

Set up with a wide stance, upright torso. Rotate and flex at the hips reaching your right arm to left foot. Rhythmically transition, with rotation to right side with left arm. Keep neutral spine, focus on hip flexion rather than lumbar flexion.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31



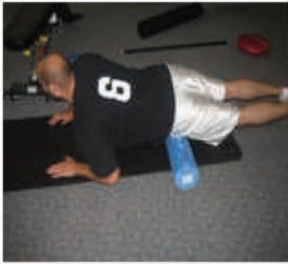
**Foam Roll Low Back**

Begin sitting on foam roller with roller just at the top of the glutes. Use legs and arms to roll up to the mid-back. Roll back and repeat.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31



Notes:

**Psoas roll**

place roller just below hip bone and roll up onto your belly and back

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



Notes:

**Foam Roller Abductor**

place roller under groin area and move from side to side

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



Notes:

**Plank**

On elbows and toes keep spine neutral hold trunk off floor

Do not let Low back drop, Shoulders shrug  
Upper back round.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
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15	16	17	18	19	20	21
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Notes:

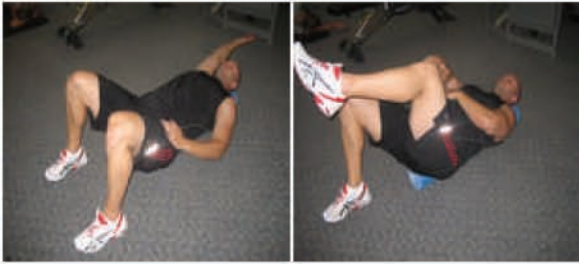
**Foam Roll QL**

Begin side lying on a foam roller with roller just above the top of the hip. Use arm and leg to roll up the side to just below the ribs. Roll back. Repeat.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
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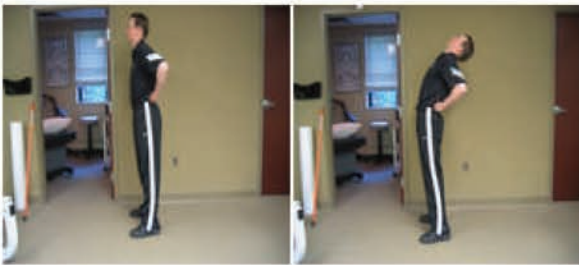
**Dead Bug w/ Foam Roller**

On a foam roller touch opposite arm to leg concentrate on a neutral spine and dont let roller move

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



**Back extensions**

Stand with your feet apart. Place both hands on your low back and lean back as far as possible. Don't bend your knees and move from your low back. Discontinue if you experience leg or low back pain.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



**Wall Slide / Arm Elevation**

Stand with back against a wall with head touching wall and chin tucked in. Place feet a few inches away from the wall and raise arms above head. Squat body down the wall keeping arms elevated. Keep low back flat on wall with just a finger space. Actively exhale while performing squat to feel a stretch in the mid back.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

## CHAPTER 11

1. Which of these muscles make up the core?
  - A. Transverse Abdominis
  - B. Internal/external obliques
  - C. A & B
  - D. Hamstrings
2. Where do the external obliques attach in the body?
  - A. Lower ribs
  - B. Upper spine
  - C. Neck (C2)
  - D. Lumbar (L4)
3. What muscle in the core helps counterbalance all forces involved in spinal flexion?
  - A. Quadratus Lumborum
  - B. Erector Spinae
  - C. Transverse Abdominis
  - D. Glutes
4. What is the largest Spinal stabilizer?
  - A. Rectus Abdominis
  - B. External Obliques
  - C. Erector Spinae
  - D. Latissimus Dorsi
5. What muscle supplies tensile support to the lumbar spine?
  - A. Latissimus Dorsi
  - B. Rectus Abdominis
  - C. Thoracolumbar Fascia
  - D. Rectus Femoris
6. Dynamic stabilization must be included to increase proprioception and stability in the trunk, as well as in the rest of the body.
  - A. True
  - B. False

7. In General, the most effective type of core training is when one is
- A. Lying down
  - B. Sitting
  - C. Standing
  - D. Mimicking life movements and targeting weakness
8. What is (are) great tool(s) for training that core?
- A. Medicine balls
  - B. Stability balls
  - C. Balance boards
  - D. All of the above
9. The proper progression of a plank is
- A. On wall, knees, toes
  - B. From toes, wall, knees
  - C. Knees, wall, toes
  - D. None of the above
10. When doing the hip hinge it is ok to round the back?
- A. True
  - B. False

# CHAPTER 12

## Foam Rollers



## Our Central Nervous System

Over time, our bodies may develop structural imbalances, excessive scar tissue, trauma from injury, and painful points along a muscle or in the fascia. These 'trigger points' can cause a restriction in blood flow to the muscle, shortening of the muscle, and possibly inflammation and pain. Any one of these problems can inhibit proper posture, effective exercise form, proper joint alignment and poor neuromuscular transmission, potentially setting the stage for a more serious injury. Trigger points also put a strain on surrounding muscle and tissue that must compensate for the weakened area.

Foam rollers are an excellent method of myofascial massage. They break down the scar tissue that has formed, thereby returning the blood flow and nervous system transmission to/from the area. Removing the 'knots' will also allow for exercises to be effective in returning the structural balance and joint stability to the area, and removing the stress on the muscles that have been compensating for the weak area. Greater flexibility will also be achieved.

To correct poor movement patterns, one has to become aware of the pattern they've adopted, and retrain their brain and central nervous system (CNS). Small, precise movements are the most effective way to retrain the CNS, and restore the correct muscle movement pattern.

Foam rollers are one tool that can be used to accomplish this task. They are hard, cylindrical and unstable, and their use requires complete concentration. Therefore, they are not only used for muscle exercises or treatments, but are brain exercises as well. Total focus is required to maintain stability. Foam rollers can be used so many different ways, it is difficult to list them all. On the following page are some examples to help you create your own exercises.

It is important to be able to activate our core musculature for stability and balance, not only for anyone involved in any type of sport, but also in our day-to-day lives. As we age, we typically don't engage in activities that require using our stabilizer muscles.

Some research suggests that exercises on an unstable surface, or exercises done on one leg challenge the core muscles to fire and aid in a person's proprioceptive awareness – your body's awareness of its limbs in relation to the rest of your body, and the environment or space around it. After an injury, for example, an athlete may find their performance and accuracy aren't what they were before. This may stem from the inability of the necessary muscles to send and receive signals to and from the brain. Proper force generated in our core translates to proper force and movement in the rest of the body.



### Foam Roller DB Press

Lying on a foam roller perform a standard dumbbell press  
keep feet shoulder width apart  
maintain neutral spine

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:



### Foam Roller Push Up

Place hands on foam roller  
keep spine neutral  
dont let roller move  
feet wider makes it easier  
arms should be less than 90 degrees in relation to trunk

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:



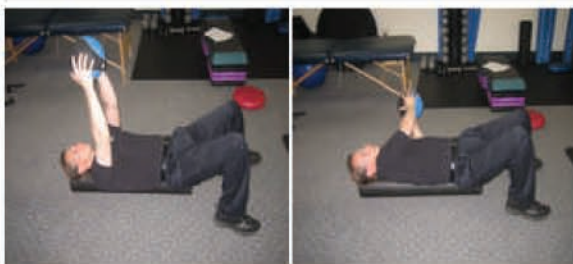
### Foam Roller Fly

Place roller under back  
feet shoulder width apart  
keep spine neutral  
perform flyes

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:



### Med ball twist

Lie on foam roller with feet on the floor and holding med ball. With arms straight and keeping neutral spine and back on foam roller, move med ball from side to side. Tip the hip with the shoulder to avoid twisting back. Return and repeat.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:



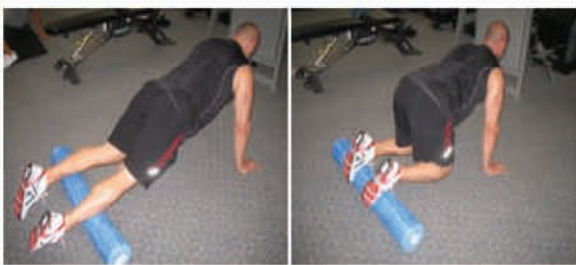
### Dead Bug w/ Foam Roller

On a foam roller touch opposite arm to leg concentrate on a neutral spine and dont let roller move

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



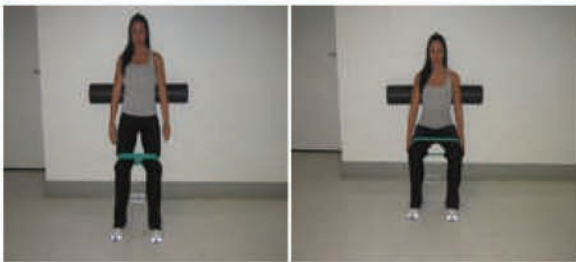
### Foam Roller Prone Knee Tuck

In a push up position place roller just below knees tuck roller while holding a neutral spine and dont let the knees pass 90degrees

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



### Foam Roller Squat w/band

Place band around legs,Just above knees. Place roller between lower back and wall. Squat down and keep band tight and legs out. Keep abdominals tight.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



### Wall Sit

Place foam roller between lower back and wall. Slide down wall keeping abs tight and sticking tail out. Hold

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



### Foam Roller Supine Tuck

Lie on back and place heels on roller. Lift body off ground, keep abdominals tight and draw roller in while shifting from heel to toe. Use the hamstrings to pull in the roller.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:



### Foam Roller Plank

Place elbows on foam roller and toes on floor. Maintain a neutral spine and do not move roller.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:



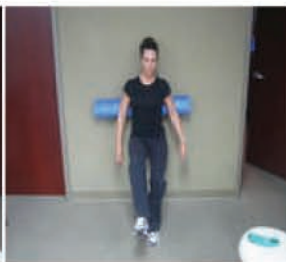
### Half Roller Bird Dog

Place 2 half rollers on the floor in a fashion that allows your hands and knees to be in the center. Reach with opposite arm and leg keeping neutral spine and not allowing any hiking or extensor recruitment.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:



### Foam Roll Single Leg Squat

Begin against the wall with foam roller in the small of the back. Balance on one leg and then squat down being careful not to let the knee come out past the toes. Return to standing position. Repeat.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:





### Foam Roll Hamstrings

Begin with the foam roller at the top of the hamstrings, keeping the feet off of the floor. Use arms to roll down the hamstrings to behind the knee. Roll back and repeat.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



### Foam Roll Glutes

Begin sitting with the foam roller at the top of the glutes. Use legs to push up and roll to the bottom of the glutes. Roll back and repeat.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



### Foam Roll IT band

Begin lying on side with foam roller at the top of the hip. Keeping the leg being rolled off of the floor, use other leg and arm to roll down the leg to just before the knee. Roll back to the top of the hip. Repeat.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



### Foam Roll Low Back

Begin sitting on foam roller with roller just at the top of the glutes. Use legs and arms to roll up to the mid-back. Roll back and repeat.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

Notes:

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



### Thoracic stretch

Begin lying on the foam roller with roller in the small of the back. Use legs to roll up the mid-back to the top of the traps. Roll back and repeat.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:



### Foam roller thoracic mobility

Place foam roller horizontally on the floor. With knees bent and your hands clasped behind your head, lay back over the roller. Lay your mid back over the foam roller and then roll your spine back and forth slowly by flexing and extending your knees. Keep a neutral spine and keep low back down as you extend over the roller. Your head should almost touch the floor.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:



### Foam Roll QL

Begin side lying on a foam roller with roller just above the top of the hip. Use arm and leg to roll up the side to just below the ribs. Roll back. Repeat.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:



### Foam Roll Gastroc/Soleus

Begin with foam roller behind the knee with one leg crossed over the other. Using arms to support the body, roll down to the ankle and back. Repeat.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

- 1 2 3 4 5 6 7
- 8 9 10 11 12 13 14
- 15 16 17 18 19 20 21
- 22 23 24 25 26 27 28
- 29 30 31

Notes:



Notes:

### Foam Roller Adductor

place roller under groin area and move from side to side

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



Notes:

### Foam Roller Lat

lying on your side place roller under you tip back slightly so you can really focus on lats use legs to move up and down

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



Notes:

### Quad roll

Place roller just above knees and roll up to hips then repeat. Tipping onto one side will focus on that side.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



Notes:

### Psoas roll

place roller just below hip bone and roll up onto your belly and back

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

## CHAPTER 12

1. What are the benefits of Myofascial Massage?
  - A. Break down scar tissue
  - B. Return blood flow to the area
  - C. Increase nervous system transmission
  - D. All of the above
2. Foam Roller Myofascial massage can Increase flexibility.
  - A. True
  - B. False
3. During A Foam Roller DB Press, The feet should be
  - A. Less than Shoulder width
  - B. Shoulder width
  - C. More than shoulder width
  - D. Placed right next to each other
4. During the medicine ball twist, the arms should be bent.
  - A. True
  - B. False
5. During the foam roller Bird Dog, the spine should stay neutral.
  - A. True
  - B. False



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# CHAPTER 13

## Basic Program Design

## Basic Program Design

In order to design a successful fitness program, it is essential to establish and understand the primary purposes of that program. Phases, or cycles, should be built into each program in order to obtain consistent challenge and overload for the participant. Each cycle should include certain parameters with realistic goals and progressions for the particular phase. Each phase should be a progression of the last; changing tempos, rep ranges, rest periods and order of body parts insures a balanced program. Generally a phase should last anywhere between two and six weeks depending on exercise frequency, client progression and goals. First and foremost, a thorough evaluation must be conducted to identify faulty movement patterns and postural distortions. The findings of your evaluation will ultimately guide you in the program design and customize it for your client. Any deficiencies noted during your evaluation will require attention in order to correct and build a strong fitness foundation for the participant. You need to ensure the client engages in proper warm-up activities according to the movements (both aberrant and normal) acknowledged in their initial evaluation. Dynamic warm ups and postural control exercises are a great way to get started. Effective program design is truly a fluid process, and it is important to keep in mind that program design should be based on initial as well as ongoing evaluation findings.

A well-designed fitness program will not only address goals but function as well. The client may have specific objectives in mind but the body needs to have a functional baseline in order to achieve such goals. For example, the participant may have an ambition of hypertrophy in the pectoralis major muscles. However, if their pectoral muscles exhibit restricted flexibility and will eventually create a cascade of dysfunction for the entire shoulder girdle, does it make sense to pursue the client's desire at this point in time? If the participant is insistent upon doing an exercise you feel is detrimental to their overall health and achievement of their goals, it is your job to educate them and provide them with a comprehensive explanation as to why certain exercises and movements may not be prudent. Demonstrate their weaknesses to them and describe their effects on their daily activities. You must target weak muscles and address any flexibility issues right from the start. Introduce shoulder stability and back strengthening exercises in the situation just discussed. If you approach program design with function in mind, you will be providing the client with sound principles upon which they can build. Progression is paramount; it's always better to err on the side of caution and be too easy than too hard. The outcomes of each session will dictate short-term as well as long-term progression.

While function should be the cornerstone of program design, how does this translate into keeping your client interested? The average person with some postural issues or muscle weakness will not want to perform rehabilitative exercises for an hour. Generally, if the participant doesn't break a sweat or become winded, they don't feel like they did anything. You need to keep them motivated by giving them safe and easy exercises they can master quickly. If someone has many issues you can have them perform a circuit of two rehab exercises and one weight-lifting exercise, even if it's not "functional". The majority of your workout should be functional, but tossing in some safe, old-school basics can spice things up a bit and keep your client interested. Remember: client satisfaction and progression in form and function are the hallmarks of effective program design.

## **Basic guidelines:**

Heavy weight training and/or explosive movements should be avoided with beginners. With beginning clients, performing more sets of lower reps is better because it increases motor skill development while encouraging less fatigue. Teaching form is of utmost importance no matter how experienced your client, because you can actually create faulty motor patterns if the form is not disciplined. Also, it is important to provide a thorough explanation of how and where cardio training fits into a resistance-training program.

Minimize the amount of exercises to be performed in each session. You are teaching proper mechanics, and repetition and practice is paramount -- if you do one to two sets of 15 different exercises, they will never master the form of any of them. There are no fixed guidelines on how many exercises you should include, because it will be established on the individual's performance on that particular day. However, a good baseline is as follows: include full body movements as they progress from floor exercises and focus on mastering body weight before adding resistance.

Once a person has demonstrated they are ready to do more difficult exercises, start to incorporate multi-tasking exercises. Don't do the same program for more than 4-6 weeks. You need to vary repetition ranges as well as the amount of sets, tempos and rest periods. Include super sets and tri-sets. While diversity is important, don't change the workout every time. Basic structure and consistency is necessary and it will be impossible to track progressions if you do something off the top of your head every time you see them. The majority of the workouts should be uniform so that progress can be measured, and variety can be added so that the client is consistently challenged.

## **How to choose what program fits the person**

As a trainer, you will meet many different people. Some are serious and very competitive while others are just recreational athletes or average people who just want to exercise for health and stress relief. It is important to recognize some of general qualities associated with different individuals, because you need to address both the physical and mental needs of your clients in your program design. Below are some basic guidelines and suggestions to help you get started. Program design is complicated and takes practice. This manual only focuses on basic principles only; advanced principles are offered in our other manuals.

The serious athlete: Needs strict attention and exercise selection must be precise. Programs must be well thought out and every detail accommodated. Very competitive by nature, so workouts must be challenging and specific to the sport. Super sets, dynamic core training, plyometrics and heavy training when appropriate should be a big part of your program. This person will do whatever program you give them and will follow it even when you are not there. Incorporate weight-training as much as their sport will allow. Don't overlook the "small stuff":

athletes compensate very well and need to be told when they are doing something wrong. Show them how flawed they are at the easy postural and core exercises that many trainers forget about. You need to be very confident and have a strong background to train this individual correctly and successfully.

The recreational athlete: Requires strict attention and workouts need to be functional with some general weight lifting exercises. They love sports and enjoy exercise in general. Usually has some gym experience and will want to do non-functional exercises for enjoyment, but will do all sport-specific exercises you teach them. Super sets, dynamic core training, light plyometrics and semi-heavy training when appropriate should be a good part of your program. Progression is important, these individuals want to be challenged and exposing their weaknesses will only fuel their determination. They will do most of what you tell them on their own but will be more inclined to play or practice their sport than work out in the gym. Optimally, they should train with weights 3x a week, but 2x per week is what they will normally deliver.

Exercise Enthusiast: This person lives to exercise and will stop at nothing to get into shape. Most of the time this person does all the wrong things and it's your job to change their mind. Exercises should be functional and geared towards toning and muscle building. Target areas they complain about and pay careful attention to progression. These clients are posing in the mirror alone at night, so make sure they see results. They will follow whatever you give them if they believe you. Program design should include 4-5 days or they will be unhappy and go to the gym on off days and do whatever they want. Be certain to design a program that doesn't over train them but keeps them in the gym and happy.

Weight Loss: This person wants to get in shape and feel better. This individual usually doesn't play sports but may have in the past. He/she also doesn't love exercise but understands it's the only remedy for permanent weight loss. Workouts should be focused on getting them to sweat and raising and lowering heart rate. Exercises should relate to every day activities and gross movements for maximal calorie burning. Circuit training is a good routine for these participants. Exercise prescription should be geared toward 3x week but these people love cardio and compliance is usually difficult. They will strength train with you and perform cardio on their own, despite your recommendations.

The Gym Hater: This person hates exercise and anything related to health.

There are a few reasons they come in:

- You are a great salesman and convinced them it was in their best interest;
- Their doctor told them they need to exercise for health reasons;
- A family member forced them;
- They feel terrible and want to do something to stop feeling guilty.
- They usually don't play any sports and have been out of shape a long time. These clients will not do anything unless they see you. It's your job to keep them moving but comfortable. They do not want a hard workout and anything beyond simple exercises makes them upset. The best routine is circuit training and when you see them getting tired, slow the pace and do some really easy exercises. Try and keep it fun and do the best you can to keep them motivated. You are helping them even if you feel your workouts are not the model of efficiency. With these folks, doing something is the name of the game!

When considering program design for beginners, a general suggestion is to design it for an initial twelve week period: four, three-week cycles with gradual progression assuming the client is reaching desired/assigned targets. The first stage is geared towards correcting postural issues, teaching form, defining exercise boundaries, and addressing balance and faulty motor patterns. Repetition ranges will vary from six to ten at slow tempos and low intensity. The second stage is almost the same with less static exercises and increasingly difficult exercises at a faster tempo and slightly more intensity. Repetition ranges can be higher with ten to fifteen repetitions. The third stage should have more dynamic movements at a moderate intensity and include super-setting and challenging environments. The fourth stage should be difficult, full-body, multi-joint and proprioceptive exercises. Intensity is based on goals.

\*We wish to emphasize that the guidelines suggested here are simple in theory and presented as a starting point basis. This is not an all-inclusive approach to program design; in fact, our intent is to offer the fitness professional a foundation upon which to build. We offer more comprehensive, in-depth program design courses and provide suggestion reading/educational materials on our website.

## Circuit Training

Circuit training involves performing a series of exercises with little or no rest at the end between each exercise. The series can be as few as three exercises or as many as five or six exercises performed consecutively. Once the series of exercises has been completed, a rest period of one to three minutes is allowed before commencement of the next circuit. Circuit training routines are typically best for weight loss or rehabilitative situations, but they can easily be designed and/or modified to suit the needs of any individual – from a beginning novice to a well-conditioned athlete.

Circuit design will vary depending on the needs of the individual, but the exercises should be structured in a fashion which incorporates use of alternate muscle groups to facilitate recovery. Exercise selection should be geared toward functional-type movements, because circuit training is often used as a method for building foundational strength. Well-chosen functional exercises will not only develop the prime movers but help to condition core musculature, a key consideration in any exercise program. The overall goal of circuit training is to allow for anatomical adaptation in a structured manner with less risk of overload to the client due to alternating muscle groups.

You can easily control the intensity of a circuit routine by speeding up the exercises, super-setting or increasing or decreasing rest periods. Circuits for novice athletes should be designed to address as many muscle groups as possible because you are trying to create a strong foundational base upon which they can build in the future. Therefore, beginning circuits will result in the use of more stations and ultimately longer circuits. Design for experienced athletes should include a reduced number of stations but a change in pattern between circuits.

General training parameters for circuit training will vary on the level of the participant, and it is from this level that you can use to design the circuit workouts. For example, a recommended frequency for training for novice clients is 2-3 days per week and for experienced athletes, 3-4 days per week. Some sessions can involve full-body training while others can focus on specific muscle groups. If the participant is training three times per week with one day of rest between training sessions, their workouts can be structured as follows: Day One: Full-body, focusing on large muscle groups; Day Two: Core and balance exercises; and Day Three: Full-body focusing on the smaller muscles. If the participant is training on two consecutive days, you can design each circuit to focus on alternating muscle groups on the upper body on day one, and the lower body on day two. You can do different rep ranges and tempos for different body parts in the same workout to add variety. It is important to remember that the total physical demand for each client must be increased progressively with the individual in mind in order to maximize anatomical adaptation. Therefore, a novice participant will require approximately 8-10 weeks for such an adaptation, while an experienced exerciser will require programming change after a maximum of five weeks.



## Athlete program design guidelines

When designing a conditioning program for athletes, it is important to take into consideration the time of year it is for the athlete. Periods to take into account include off-season, pre-season, in-season, and post-season, with cycles or phases incorporated within each period. Workouts must accommodate the primary sport(s) in order to avoid over-training. Program design for athletes is similar to that for other individuals in that initial and on-going evaluations will determine the structure of the workouts and adjustments must be made accordingly.

Despite such similarities, all sports have different demands and training programs must take into account the dominant energy system utilized. Frequently coaches have athletes running long distances, which in many cases is counterproductive. Instructing a squash player to run five miles makes little sense when you consider that no squash court covers that distance! Cardio work should be done in intervals related to the sports demands and rest periods. Sport-specific drills should be a big part of the program and be based on athletic movements during game play. Below is a sample program for squash players who are new to weight training:

### **Off-season**

Rep ranges: 6-10

Tempos: 4/0/1 and 3/0/x

Rest periods: 60-120 sec

How many days in the weight room per week? 4-5

Phase 1: Concentrate on gross movements and form with slower tempo.

Duration: 3-4 weeks

Phase 2: Gross movements at an explosive tempo – the focus is on power and explosion.

Exercises should increase in difficulty as time progresses.

Duration: Until pre season

### **Pre- season**

Rep ranges: 6-8

Tempos: 3/1/1

Rest periods: 45-60 sec

How many days in the weight room per week? 3-4

Phase 1: Focus on power and building endurance strength. Variety can be implemented with incorporation of bi-sets.

Duration: 3-4 weeks

## **Pre-season** (Cont'd)

Phase 2: Perfecting and getting ready to play. Drills will increase in intensity; heavy lifting will still be involved, but changes will be incorporated. Higher reps will be used with the power exercises, e.g., one gross exercise performed slightly heavy for 6 repetitions, followed by a 15-repetition, easier exercise.

Duration: 2 weeks

Rep ranges: 8-10

Tempos: 3/0/1

Rest periods: 60-90 sec

How many days in the weight room per week? 3

## **In-season**

Rep ranges: 6-8

Tempos: 3/0/x or 3/0/1

Rest periods: 10- 45 sec

How many days in the weight room per week? 3 or from whatever the athlete can recover.

Phase 1: Adjusting to playing and training together. Continue explosive lifts but decrease frequency and avoid high risk exercises. Keep workouts a bit shorter and avoid a lot of aerobic activity.

Duration: 4-6 weeks

Phase 2: Continue explosive lifts but further decrease frequency. Incorporate more flexibility and recovery exercises.

Duration: Until post season.

Phase 3: Usually occurs around crunch time(whos making it to postseason play). Everyone is different as a general rule it is prudent to keep the workouts to a moderate intensity and eliminate explosive weight training. Focus more on drills and explosive, on-court movements. Increase time passively stretching the athlete.

Duration: until end of season

## **Post season**

Rep ranges: 12-20

Tempos: 5/0/1

Rest periods: 30-120 sec depending on weaknesses

How many days in the gym per week? 3-4

Phase 1: Higher reps for recovery. Don't overdo it the athlete is playing their hardest at this point.

Duration: until the end of the season. After their final match give the athlete a week or two to recover. Don't do any weights just stretches and really basic simple movements.

# EVALUATIONS

Name \_\_\_\_\_

Today's date: \_\_\_\_\_

Phone (h) \_\_\_\_\_ (w) \_\_\_\_\_

Address \_\_\_\_\_

Email \_\_\_\_\_

## MEDICAL INFORMATION

**When was your last complete physical examination?**

**What were the results?**

List any **medications** you are currently taking, or have taken in the past 6 months. Provide the reason they were prescribed.

**List any operations that you have had (include date):**

Are **you** on a special diet?

Have any member of **your** immediate family (mother, father, sister, brother) had:

Heart disease	Hypertension	High Cholesterol	Heart Attack
Diabetes	Stroke	Obesity	

**Indicate any of the following which currently or have existed in the past, and note when:**

Anemia_____	Arthritis_____	Asthma_____	Back pain/injury_____
Bursitis_____	Cancer_____	Diabetes_____	Dizziness_____
Epilepsy_____	Headaches_____	Heart problems_____	Hernia_____
Hypoglycemia_____	Joint problems_____	Kidney problems_____	Liver disease_____
Lung disease_____	Shortness of breath_____	Ulcer_____	Weight problems_____
Chest Pains_____	High blood pressure_____	Thyroid problems_____	High cholesterol_____
Osteoporosis_____	Neurological Disorder_____	Other_____	

Do *you* currently smoke? \_\_\_\_\_ Have *you* ever smoked? \_\_\_\_\_ Age: \_\_\_\_\_

**Are you pregnant or trying to become pregnant?** \_\_\_\_\_

### **BLOOD PRESSURE:**

Explain your current eating habits

How many times do you eat per day?

Do you take any supplements?

How do you spend your day at work?  
Sitting at a desk walking/ active highly active

Hours of sleep do you get each night? \_\_\_\_\_  
Hours per week \_\_\_\_\_

How would you rate your daily stress level? \_\_\_\_\_ Rate your daily energy level? \_\_\_\_\_

Do you enjoy exercising? \_\_\_\_\_ How often do you perform resistance training? \_\_\_\_\_  
How often do you perform moderate exercise? \_\_\_\_\_ Vigorous exercise? \_\_\_\_\_

How would you rate your current fitness level?  
Poor Below Avg. Moderate Above Avg. Excellent Competitive Athlete

List any other factors which might affect your safe participation in a fitness program?

Weight \_\_\_\_\_ Height \_\_\_\_\_ Body Fat \_\_\_\_\_ Measurements: Waist \_\_\_\_\_  
Thigh \_\_\_\_\_ Chest \_\_\_\_\_ Arms \_\_\_\_\_  
Lowest weight \_\_\_\_\_ Highest weight \_\_\_\_\_ Favorite weight \_\_\_\_\_

Personal Goals: (circle all that apply)

- |                        |                     |                                |
|------------------------|---------------------|--------------------------------|
| Weight loss lbs. _____ | Improve strength    | General Fitness                |
| Reduce risk of disease | Improve Flexibility | Improve cardio Vascular Health |
| Improve posture        | Tone and firm       | Injury Rehabilitation _____    |
| Strengthen Bones       | Exercise regularly  | Balance and Stability          |
| Other _____            |                     |                                |

Please list anything else that will help provide a better Fitness Program:

**Rest HR** \_\_\_\_\_ **Max HR** \_\_\_\_\_ **Recovery HR** \_\_\_\_\_

NOTES:



### Squat

Start feet shoulder width apart and squat down.

Check for

Knees caving in      tight adductors  
 Hyperpronation      weak intrinsic foot muscles  
 Cant get to 90      tight hips and hamstrings  
 Leans forward      weak trunk/poor hip mobility  
 Hip drops      weak glute medius  
 patella sheer      weak hips/quad dominant  
 Pelvic shift      poor hip stability  
 Poor balance      weak glute max

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:

Basic suggestions  
 foam roller squat  
 peterson step up  
 glute bridge



### 1 Leg Stance

Have client pick up one leg. Also do test with eyes closed

Check for

Pelvic shifting (hip dropping) - weak glute med  
 Pelvic swaying - weak glute med and core  
 Knee shaking - weak popliteus, calf, quad  
 Hyperpronation of foot - weak peroneals, intrinsic foot muscles  
 Weak glute med causes opposite side low back pain

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:

Basic suggestions  
 balance boards  
 1 leg med catch  
 chops



### Push Up

Have client perform a push up

Check for

Trap elevation      tight upper traps/weak lower  
 Scapular winging (medial border) weak serratus  
 Scapular winging (inferior angle) weak rhomboid  
 Scapular adduction      tight rhomboid/weak pec  
 Poor lumbopelvic stability      weak core  
 Delay scapular movement      poor proprioception

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:

Basic suggestions  
 serratus push up  
 knee push up  
 planks





**Side Bridge Endurance Test**

Have patient perform a side bridge

Check for

How long they can hold it

Hip dropping

Hyperextension of low back

Shoulder shrugging

Inability to extend hip

Kyphosis

Shoulder pain

This test will reveal shoulder/core weakness

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

**Notes:**

Basic suggestions  
knee planks  
dead bug on roller  
corkscrew



**Crossovers**

This tests trunk stability

Start in a push up position. Legs spread wider than shoulder width. With back straight, touch one hand to another and return to starting position without shifting your body.

Immediately do the same thing with the other hand and continue to alternate.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

**Notes:**

Basic suggestions  
planks  
disc crunch  
low chop

Cant keep neutral spine

Trap hiking

scapular winging

hip rotation



**Dead Bug w/ Foam Roller No Arms**

Place roller along spine, plant feet on floor and hold a neutral spine then pick up 1 foot and stabilize with the other

Check for on each side

Knee shaking

Trunk shaking

Cant hold position

Inversion of foot

Eversion of foot

Back pain

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

**Notes:**

Basic suggestions  
glute bridging  
clams  
planks



**Hip Hinge**

A: Correct: Keep spine straight by hinging at the hips.

B: Incorrect: Spine bends forward putting low back in a harmful position.

Hold pole against back of head and tail bone  
Once the pole breaks from the body clients not using their hips. Client may bend knees to get lower. Master this before doing any weights.

This is not so much a test its just a way for you to see how poor bending mechanics are.

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:



**Lunge**

Start w/ feet shoulder width apart. Step forward w/ knee bent and lower back knee toward floor keeping neutral spine, return to start.

Check for  
Knee adduction/shaking/pain      tight adductors  
Pronation of foot                      weak intrinsic foot muscles

Leaning forward                      weak core/glute max  
Pause on return      overall lower body weakness  
Can't reach floor with back knee      tight quad  
Patella sheer                          poor hip mobility

Sets:	
Reps:	
Weight:	
Hold:	
Rest:	

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Notes:

- Basic suggestions
- 1 leg balance exercises
- supported static lunge
- split squat





## CHAPTER 13

1. The time of year is not an important factor when designing a program for athletes
  - A. True
  - B. False
2. For a squash player during the off season, how many times a week should they hit the weights?
  - A. 1-2
  - B. 2-3
  - C. 3-4
  - D. 6-7
3. Explosive lifts should begin during the phase 1 of a squash players off-season routine
  - A. True
  - B. False
4. During an In-season routine it is important to continue explosive lifts and increase the frequency
  - A. True
  - B. False
5. During the post season; the rep ranges should be
  - A. 6-8
  - B. 8-10
  - C. 12-20
  - D. 20-25
6. After finishing the last match, all that should be done for a couple weeks is stretching and basic simple functional movements.
  - A. True
  - B. False
7. When designing a program for an athlete it is important to take into consideration the time of year it is for the athlete?
  - A. True
  - B. False

8. Periods to take into account for athletes include
- A. Pre season
  - B. Post season
  - C. In season
  - D. All of the above
9. Circuit training involves performing a series of exercises with
- A. No resistance
  - B. Little or no rest between exercises
  - C. Long rest between exercises
  - D. Both a and b
10. a safe and easy way to control the intensity of a circuit routine would be
- A. Adding weight
  - B. Reduce water intake
  - C. Speeding up the exercises
  - D. None of the above
11. Beginner weight lifters should avoid
- A. Heavy weight or explosive movements
  - B. Light weight and high repetitions
  - C. Cardiovascular exercise
  - D. Both a and c
12. The best candidate for circuit training is;
- A. High performance athlete
  - B. Weight loss client
  - C. Rehab client
  - D. B&C
13. Exercise selection should be geared toward functional type movements
- A. True
  - B. False
14. How can you control the intensity of a Circuit routine?
- A. Increasing or decreasing rest period
  - B. Speeding up the exercises
  - C. Super-setting
  - D. All of the above

15. What is a good example of a 3 day per week circuit program with one day of rest in between
- A. Day1-Upper Body; Day2- Lower Body; Day 3- Upper Body
  - B. Day 1- Chest/triceps; Day 2 – legs/core; Day3- Back/Biceps/shoulders
  - C. Day1-Full body; Day2-core/balance; Day3-Full body
  - D. Day 1 – Legs; Day 2- Chest and Triceps; Day 3 – Back and Biceps
16. If a client is working two consecutive days while circuit training it is generally ok if the hit the same muscles with the same intensity both days as long as they rest the third day.
- A. True
  - B. False
17. Circuit Training involves performing a series of exercises with a considerable amount of rest at the end between each exercise.
- A. True
  - B. False
18. In season training should consist of
- A. Building endurance
  - B. Gross movements and form with slower tempo
  - C. Both a and b
  - D. None of the above
19. Circuit Training involves performing two exercises with a 1 minute rest then performing another set.
- A. True
  - B. False
20. Exercise selection should be geared toward functional type movements
- A. True
  - B. False



# CHAPTER 14

## **The Truth Behind The Most Popular Gym Exercises**

*This section focuses on exercises that are often performed in every day routines. We are going to point out the problems with these specific exercises and suggest alternatives.*

## Bad: Smith Machine Squats



- Fixed plane of motion
- Takes pressure off of the back, but puts significant pressure on the knees
- Minimizes hip extension, which takes hamstring involvement out of the exercise
- The hamstrings, however, are the muscle group that helps to stabilize the kneecap
- Alternative: The box squat

## Alternative: Box Squats



- Wrong:  
Tendency to sit on bench with weights. Rounding the back
- When you perform box squats, position the barbell on your shoulders then position yourself near a box, or bench, as shown above. Descend under control until you feel the bench touching you then push through the weight upwards until you reach the initial position again.

\* Never sit or rest on the bench with the weight on your back! Remember to keep your back as straight as possible and your abs tightened throughout the lift.

## Bad: Smith Machine Bench Press



- Fixed plane of motion
- Works same muscle fibers each rep
- Takes the natural motion out of the movement
- Puts extra pressure on the shoulder joints
- Alternative: Barbell Bench Press or Dumbbell Bench Press

## Alternative: Barbell Bench Press



- Place feet flat on the floor under thighs.
- Keep shoulders pulled backward and down toward the hips.
- Hold bar with wider than shoulder width grip, keeping elbows less than 90 degrees in relation to the shoulder.
- Lower bar to chest and press up.



## Bad: Leg Extension



- The four parts of your quadriceps are designed to work together as one. Recent study in Medicine and Science in Sports and Exercise found that leg extensions activate the sections slightly independently of one another. Even a five-millisecond difference can cause uneven compression between the kneecap and thighbone, inflaming the tendon that connects the kneecap to the shinbone.
- This exercise should only be done under very specific circumstances in rehabilitation setting. This movement puts a tremendous amount of torque on the knee and since the resistance is placed across the shin and not along the length of the bone, the bones are pressed backward putting tremendous stress on them.
- When done for rehabilitation purposes, a very specific range of motion should be used and the shin pad should be placed higher up on the lower leg and the resistance should not start at any more than a 90 degree angle.

## Alternative: Single Leg Squats



- Start with one leg out in front of the body keeping the knee and foot in line with hip. Opposite leg should be resting on stepper or bench
- Perform a half squat
- Return and repeat



## Bad: Behind the Neck Press



- Just as a posterior pull down strains your shoulders on the way down, this exercise hurts them on the way up. It also puts increased stress on the acromioclavicular joints (little knobs on the tops of your shoulders), which can lead to an overuse injury.
- Increased risk of Cervical spine injury

## Alternative: Seated Shoulder Press



- This exercise can be done with proper shoulder flexibility in certain circumstances. Most people don't have good flexibility or a need to do this motion anyway so avoid it.
- Sitting tall on ball holding weights at shoulder level with palms facing forward.
- Keep shoulder blades down and back while pushing weights straight up over head.
- Do not touch weights together overhead, keep them shoulder width apart.

## Bad: Behind the Neck Pulldown



- Potential rotator cuff strain
- Potential cervical spine injury

## Alternative: Lat Pull down to the Front



- Grasp lat bar at outer most bend with overhand grip.
- Bring lat bar to upper chest by pulling the upper arms and shoulder blades downward and backward.
- Maintain the natural curve of the back.



## Bad: Traditional Sit Up



- Repeated lumbar flexion
- Strain on cervical spine
- Recruits more hip flexors than abdominals

## Alternative: Crunch with a Dynadisc



- Place dyna disc under low back.
- Start with back off the floor, crunch up and return to start.
- Try to shift the air while maintaining a neutral spine.
- Avoid touching the floor.

## Bad: Leg Raise



- Over activation of the psoas
- Low back pain



## Alternative: Cross Bridge on Foam Roller



- Lie on foam roller with feet on the floor and holding medicine ball.
- With arms straight and keeping abdominals tight and back on foam roller, move medicine ball from side to side.
- Return and repeat.

## Bad: Bicycle Crunches



- Over activation of the psoas
- Low back strain
- Neck Strain

## Alternative: Transverse Cable Chops



- Keeping abdominals tight and back straight.
- Twist from your trunk while pulling through with your arms.
- Repeat

## Bad: Sit Up Machine



- Forced lumbar flexion
- Locked range of motion



## Alternative: Crunch on the Stability Ball



- Lie back with ball supporting low back.
- Place fingertips behind head but don't pull your neck. Look at the ceiling and don't poke chin.
- Crunch your body forward raising shoulder blades off ball. Do not come up too high and flex the spine.
- Lower back down, but avoid shoulder blades touching the ball.

## Bad: Superman



- According to the research of Stuart McGill PhD. he finds that this exercise results in over 6000 N (about 1300 lbs) of compression to a hyperextended spine, loads the facets, and crushes the interspinous ligament.
- Stuart McGill PhD. proclaims "This is a poorly designed exercise."

## Alternative: Quadruped Alternate Arm-Leg Raise



- Start on all fours with knees under hips and hands under shoulders
- Brace the stomach, squeeze the glutes
- Press the heel straight back to straighten the leg while keeping the torso level



## Bad: Hack Squat



- Patella Femoral shear
- Forced Range Of Motion

## Alternative: Foam Roller Wall Squat



- Stand with foam roller placed on low back, feet about shoulder width apart and about 2 feet from the wall.
- Keeping abdominals tight, roll body downward into a squat position, then roll back up to start. Holding dumbbells at your sides will increase the difficulty of the exercise.

## Bad: Upright Row



- Impaired Rotator Cuff Range Of Motion
- By maintaining a closed grip with palms (and thumbs) facing you, you have created internal shoulder rotation. As the bar is raised your shoulders are abducted and internally rotated creating a pinching combination. As the soft tissue structures within the shoulder are pinched they become chronically inflamed.

## Alternative: Deltoid Flies



- Kneeling on incline bench holding weights straight down, palms facing each other.
- Raise arms up in an arc like motion, squeezing through the mid back.
- Keep elbows slightly bent and palms facing in hold and lower with control
- Repeat.



## Bad: Adductor Machine



- Forced Range Of Motion
- This exercise further tightens an already tight area on most people.
- The hips must simultaneously rotate and rise laterally. These actions place great stress on the lumbar spine, especially when heavy weights are used. The danger is even greater if the movement is done quickly, with a jerk, or if there is excessive hip rotation when the leg is out in front of the body
- When working the adductors, more emphasis should be put on flexibility unless directed by a professional for a specific purpose.
- Alternative: Side lunging, Sumo squat and exercises that use these muscles as synergists. Adductor Stretching is the most important thing because if these muscles are tight they can cause so many lower extremity dysfunctions.

## Alternative: Sumo Squat



- Start with feet wider than shoulder width apart and toes pointed slightly outward
- While holding weight between your legs maintain a neutral spine without letting your knees cave in or your back round forward.
- Flexibility in these muscles is most important, do not do strengthening exercises if there is tightness or dysfunction.

## Alternative: Adductor Stretch



- Standing with toes pointed forward, step out sideways into a side lunge position.
- Keep body upright by holding a chair.
- Shift weight from side to side, holding each way, to feel a stretch in the inner thigh and groin area.



## Why are braces bad?

**Knee Wraps:** Relying on wraps during regular workouts could decrease the training effect because the wraps are doing some of the lifting while your muscles aren't. There is little evidence that wraps prevent injury. They may actually do more harm than good.

Heavy wrapping can warm your knees too much, or, conversely, the tightness could cut off some circulation causing a drop in temperature weakening the muscle tissue. Tight wraps may cause damage by increasing the friction between the knee cap and leg bone. The edge of the wrap may dig into the skin causing micro-tears in the muscles and tendons.

In addition, the wraps can bunch up in back of the knees which tend to separate the joint during a deep squat. This would be similar to putting a wedge in the door jam and trying to close the door. Finally, heavy wrapping may slow down the explosiveness that is critical in Olympicstyle lifting.

**Weight Belts:** A belt is very effective for stabilizing the abdominal core area. However, it is so effective that your core muscles aren't challenged and don't develop effectively. This can leave them weak and your core unstable, fostering a reliance on the belt.

A belt should really only be used for near-maximal lifting with very heavy weights. If you need a belt to do bench presses or barbell curls, you should re-examine your form and evaluate your core strength. You may be setting yourself up for a back injury. A belt works to stabilize your core by making your abs push outwards against it.

**Lesson:** Ease yourself off the belt if you currently use one. You will need to slowly work back up to your current weights to ensure you don't hurt yourself. When you go to do a lift, brace your abs while breathing maintaining the brace. You will develop far better core strength and stability, and tighter, flatter abs.

**The following exercises are great when done correctly. We will explain the common mistakes and explain proper form.**

## Stiff Leg Deadlift



- **Wrong:** Hyper-extending or locking the knees, Going too heavy, Letting the weights hit the floor, Heels lifting, Rounding the back
- **Right:** Bend at your waist keeping your spine and neck neutral, keep back straight and knees soft. Hold bar with hands about shoulder width. Straighten up while holding the bar at arm's length. Can also be done standing on a bench or box (so that plates don't touch the floor) or with dumbbells. Picture depicts proper form.

\*A person's flexibility will determine the range on this exercise. This exercise needs to be practiced before adding resistance. People with low back injuries may be excluded unless prescribed for rehab. It may be a good idea to slightly bend the knees for beginners with tight muscles and limited range. When performing these lifts under normal circumstances it is important that the knees are not hyper extended.

## Good Morning



- **Wrong**: Rounded back with a load on the shoulders, Force hamstring range of motion
- **Right**: Place a barbell on your shoulders. Keep your head spine neutral at all times. Stand with your knees slightly bent and feet shoulder width apart. Bend at your waist until your upper body is just above parallel to the floor. Return slowly to the upper position. Picture depicts proper form.

## Hanging Hip Flexion



- **Wrong:** The majority of the movement is done with hip flexors. Do not hyperextend the spine.
- **Right:** Hanging from arm slings or chin up bar with the knees bent; draw the hips upwards until a strong contraction is felt in the abdominal. Return to the starting position under control and repeat for the prescribed number of repetitions. Remember to avoid arching or hyper extending the lower back and raise the legs by using the strength of the abdominal rather than bending at the hip. Picture depicts proper form.

\*This is a good exercise if you have proper core strength and are experienced. It is impossible to maintain proper form if you do not have good core strength. Keep the back neutral avoid arching or hyper extending the lower back and raise the legs by using the strength of the abdominals rather than bending at the hip. Do not let the legs completely straighten. Clients with back problems may be excluded. This is a very high level exercise.



## Swiss Ball Crunch



- **Wrong:** Pulling neck toward chest will cause strain to cervical spine
- **Right:** Sit on top of an exercise ball with your feet placed firmly on the floor. Roll the bottom half of your glutes off the ball by sliding forward. Your lower back should be centered on top of the ball. Place your hands on the sides of your head, but don't use your hands to pull. Look up at the ceiling and crunch by bringing lower ribs and pelvis toward each other. Don't round your back it's a small movement. This exercise should be avoided by any disc patient. Picture depicts proper form.

## Romanian Dead Lift – Performed Correctly



- **Right:** Put a barbell in front of you on the ground then grab it with a little wider than shoulder width grip. Bend the knees slightly. The position should be shins vertical, hips back and back straight. Keeping your spine and neck neutral at all times, use your hips to lift the bar. The movement should not be fast but steady and under control. The arms should remain straight. Once you are standing completely straight up, lower the bar by pushing the hips back, only slightly bending the knees, unlike when squatting. Take a deep breath at the start of the movement and keep your chest up. Hold your breath as you lower and exhale as you complete the movement. Start with light weights to get used to it and be careful! Make sure you squeeze the glutes during the movement.

## Romanian Dead Lift – Performed Incorrectly



- Wrong: Rounding of the back. Using Too much weight. Letting the weight touch the floor. Keeping head down



## Squat – Performed Correctly



- **Right:** Center a barbell behind the neck across the shoulders and traps with hands approximately half-way between the shoulders and the weights. Feet should be positioned approximately shoulder width with feet pointing slightly outward. Lower yourself under control into the squat by bending the knees and hips until the thighs are parallel to the floor. Return to the starting position by extending the knees and hips. Remember to keep your knees in line with the toes throughout the movement and keep your eyes fixed straight ahead and not upward as this may lead to neck injury. Don't bounce at the bottom of the movement and don't allow the thighs to travel below parallel at the bottom position or allow the back to deviate from the upright position. Keep the neck and spine neutral the entire movement.

## Squat – Performed Incorrectly



- **Wrong:** Rounding the back, Heels lifting off the ground, knees knocking, chin poking, excessive forward lean and keeping bar on the neck.
- Things to watch: squats are a demanding exercise and should be worked up to. Keeping form is crucial. If the person has shoulder or neck issues it may be best to do dumbbell squats and hold them at your sides. Remember you are loading the spine not just the legs so people with back injuries sometimes shouldn't squat. Core strength is very important and should be noted. It would be a good idea to get every client to be able to do some form of squat. Clients with knee injuries may need to modify the range or use a ball or roller on a wall to decrease knee torque. There is no conclusive evidence that states the knee passing the toe is bad. In fact there are times when it is necessary. A good rule is if there is no pain then the knee may pass the toe.

## CHAPTER 14

1. When performing a squat on the smith machine it will take the pressure of the back, but it will put significant pressure on the knees. Bicycle crunches are a good alternative to leg raises.
  - A. True
  - B. False
2. When performing transverse cable chops you should allow the abdominals to relax.
  - A. True
  - B. False
3. When performing bicycle crunches...
  - A. It will over-activate the Psoas.
  - B. It will cause low back strain.
  - C. It will strain the neck.
  - D. All of the above.
4. Performing the superman exercise can cause about 1300lbs of compression to hyperextend spine.
  - A. True
  - B. False
5. Performing an upright row will impair the rotator cuff range of motion.
  - A. True
  - B. False
6. The adductor machine should not be used because...
  - A. It works in a fixed range of motion.
  - B. It will cause tightness in the hip flexors.
  - C. There is excessive hip rotation.
  - D. All of the above
7. In order to perform a romanian deadlift properly you should...
  - A. Round the back
  - B. Keep the head down
  - C. use hips to lift the bar
  - D. None of the above

8. You should never round your back while performing Good Mornings.  
A. True  
B. False
9. When performing hanging leg raises you want to hyperextend the spine.  
A. True  
B. False
10. Relying on wraps during regular workouts could decrease the training effect.  
A. True  
B. False
11. When working the adductors, more emphasis should be put on flexibility unless directed by a physician for a specific purpose.  
A. True  
B. False
12. When performing the quadruped arm-leg raise the proper starting position is start on all fours, knees under hips, hands under shoulders.  
A. True  
B. False
13. The proper way to perform a stiff leg deadlift is to bend at your waist with your head up, back straight and knees soft. Hold bar with hands about 16 inches apart. Straighten up while holding the bar at arm's length. Can also be done standing on a bench or box (so that plates don't touch the floor) or with dumbbells.  
A. True  
B. False
14. Squatting on the smith machine takes pressure off of the back, but puts significant pressure on the\_\_\_\_\_.  
A. Neck  
B. Hips  
C. Shoulders  
D. Knees

15. While performing a box squat, sit completely on the box and hold for 2 seconds before standing.  
A. True  
B. False
16. Bench press should always be performed on the smith machine.  
A. True  
B. False
17. When performing the transverse cable chop, you should not twist from the trunk.  
A. True  
B. False
18. When using the sit-up machine it will cause forced lumbar flexion.  
A. True  
B. False
19. Some common mistakes that are made while performing a stiff leg deadlift are...  
A. Hyperextending or locking the knees  
B. Going too heavy  
C. Letting the weights hit the floor  
D. All of the above
20. The proper way to perform the adductor stretch is to shift weight from side to side, holding each way, to feel a stretch in the inner thigh and groin area.  
A. True  
B. False
21. Performing crunches on a dyna disc is an alternative to traditional sit-ups.  
A. True  
B. False
22. Performing leg raises may result in ...  
A. Over activation of the Psoas  
B. Low back pain  
C. A strong core  
D. Both A and B

# CHAPTER 15

## **Overtraining and Injuries**

## Over Training and Resistance Exercise

### WHAT IS OVERTRAINING?

“Overtraining is a common problem in weight training, but it can also be experienced by runners and other athletes. It occurs when the volume and intensity of the exercise exceeds an individual’s recovery capacity. They cease making progress, and can even begin to lose strength and fitness.

### WHY IS IT HARMFUL?

- Persistent muscle soreness
- Elevated resting heart rate
- Increased susceptibility to infections
- Increased incidence of injuries
- Irritability
- Depression
- Loss of motivation
- Insomnia
- Decreased appetite
- Weight Loss
- Chronic Fatigue
- Muscle and eyelid twitches

### SYMPTOMS OF OVER TRAINING

- Totally run down after a workout
- Experience chronic joint stiffness
- No longer making any progress
- Have a bad attitude towards your workouts
- Your resting morning heart rate is 5 to 10 beats per minute too high
- Experience an increase in body temperature
- Insomnia
- The development of a chronic overuse injury, usually in the joints
- Have a positive Keto-Stix reading

If you experience any of these symptoms, you may be over training.

### CAUSES OF OVERTRAINING

- Not resting long enough between heavy workouts
- Not eating enough food
- Training beyond failure in every workout
- Performing too many sets per body part
- Taking in too little protein



## States of Metabolism

There are three distinct stages of metabolism undergone in the cell; equilibrium, catabolism and anabolism.

### Equilibrium

Equilibrium can be easily defined as a fully recovered state, where energy is neither being depleted nor replenished, and structural tissue is not being damaged or repaired. As a resistance athlete, it is desirable to achieve a momentary state of equilibrium if over training is to be avoided. However, if this stage of metabolism is maintained for long periods (10-15 days or more), atrophy of the contractile proteins will result in gradual tissue loss. It is worth mentioning that the over trained athlete's metabolism, seldom, if ever, enters into the stage of equilibrium. This is because the muscle tissue never reaches a fully recovered state. Reducing the duration of intense training sessions, allowing for longer rest between workouts, and eating plenty of total calories from healthy protein and carbohydrate foods can all help to avoid over training.

### Catabolism

Catabolism is the stage when energy is being depleted and tissue damage is taking place. Catabolism obviously occurs during exercise. There are two distinctly different processes taking place; energy is depleted and structural tissue is damaged. Your ultimate goal is to "keep catabolism in the gym." If you are over training, catabolism will continue long after the workout is over. The body will continually feed off of hard earned muscle tissue for its recovery needs (gluconeogenesis).

### Anabolism

Anabolism is the stage of metabolism when energy is being repleted and tissue damage is being repaired. This is the most valuable stage of metabolism to the resistance trainee. The purpose of expending less total energy during catabolism is to allow for the post-workout presence of sufficient pyruvate (converted form of stored glycogen) to initiate anabolism. Anabolism can only be initiated in the presence of cellular recovery energy. Most successful resistance athletes know the value in ingesting a high carbohydrate post workout meal, but even these carbohydrates can be a day late, and a dollar short if the training session was too exhaustive. It takes time for digested nutrients to reach the exhausted tissues, and during this time, continued catabolism is occurring in the over trained muscle.

All things considered, you are better off slightly under training and reaching the stage of equilibrium than over training and remaining in a stage of catabolism.

## Injuries

Although sports and exercise programs offer numerous benefits, there is always the risk of injury. Athletes physically strengthen and condition their bodies with the hope of avoiding injuries but unfortunately this does not always prevent them from occurring. Every sport or activity presents different risks of injury. Regardless of the type of injury, evaluation and treatment by a professional must take place as soon as possible after the injury has occurred. This evaluation should include an inspection, physical exam, and if necessary, diagnostic testing such as x-ray, CT scan, MRI, or NCV/EMG. The time between the injury and seeking professional help will play a vital role in the athlete's recovery. The more time that passes between the onset of injury and treatment, the higher the risk of further damaging the affected tissue(s), lengthening and complicating the time of recovery.

This is even the case in minor injuries, or aches and pains that one might experience as a result of their sport or activity. It is important to listen to one's body. Pain is an alert mechanism of the brain to let one know that there is a problem somewhere in the body. Therefore, pain should be immediately addressed, and athletes should not be encouraged to play or train through pain without it being professionally addressed.

There are many different types of injuries that can occur. A large portion of athletic injuries cause damage to the soft tissues of the body. Soft tissue injuries affect muscles, fascia, tendons and ligaments, which all control and protect the joints. There are two types of soft tissue injuries, closed and open. A closed injury occurs when the soft tissue has been damaged, but the surface of the skin has not been broken. An example of a closed injury would be an ankle sprain. An open injury is the same as a closed injury except for the fact that it involves a break in the skin. An example of an open injury is a cut or scrape.

Inflammation will infiltrate the affected area, and following this, fibrosis will occur, creating scar tissue adhesions. These adhesions will not develop along the normal fiber patterns of the affected soft tissues. Instead they will form random patterns, not in accordance with these normal patterns. They may develop within the actual fibers of a particular tissue, or between different tissues all together. This will create restrictions in the function, or range of motion, that will alter movement patterns and biomechanics. As a result, other tissues will have to do extra work in order to compensate for this lack of function, and over time, may become overloaded themselves. Soft tissue dysfunction may also contribute to degenerative processes in the future. This creates a cyclic pattern of dysfunction and injury that can be avoided by seeking immediate attention.

Strains and sprains are common closed injuries that occur during sports and exercise programs. A strain is a tear in the muscle or tendon fibers. A sprain will stretch or tear ligaments, but not cause a dislocation of the accompanying joint. Both can be categorized as mild, moderate or severe. There are characteristics that help indicate the severity of the injury such as pain, temperature, redness and swelling. In addition to these, there may also be a loss of function, or range of motion.

The recommended treatment of choice after an injury has been evaluated by a professional and stabilized is PRICE; protection, rest, ice, compression and elevation. This will reduce the risk for further damage to the injured area and control the rate of bleeding.

The next step is to rest the injured area from the painful or offending activity. This will allow the body to begin the healing process, and again, prevent further damage from occurring. If the injured area is not rested, the healing process will be delayed and recovery will be slowed down.

It is also important to note that, depending on the injury, while resting from the offending activity, active and passive treatment to the injured and surrounding areas is of the utmost importance. This will allow the speediest rate of recovery. A healthcare practitioner specializing in neuromusculoskeletal injuries will determine the appropriate treatment.

While the injured area is being protected and rested, ice therapy can begin. This promotes recovery by helping to reduce inflammation at the site of injury. When blood flow is reduced, swelling and/or pain are minimized. The recommended time for ice therapy is 10-20 minutes, with a 20 minute to one hour rest period between treatments, depending on the location of the injury.

Compression can begin to be applied to the injured area. The compression should firmly lend support to the injured area but should not cut off circulation and/or blood flow.

Finally, the injured area should be elevated approximately 12 inches above the level of the heart whenever possible. This will aid in venous and lymphatic drainage of the affected region, helping reduce inflammation.

Everyone that participates in a sports or exercise program should be aware that injuries sometimes cannot be avoided. The risk of injury can be reduced by properly training and conditioning to enhance performance and function. Unfortunately, there is no way to completely remove the risk. There is no such thing as perfection in the tissues of the body so there is always the chance of overloading a tissue, causing damage. The reality is that injuries will occur when dealing with sports. They can, however, be prevented from worsening by taking some precautions. The most important thing to do when an injury occurs is to seek immediate professional or medical attention and to be evaluated and treated appropriately.

## CHAPTER 15

1. What are symptoms of over training?
  - A. Soreness
  - B. Depression
  - C. Chronic fatigue
  - D. All of the above
  
2. What is a reason for over training?
  - A. Not enough rest between workouts
  - B. Not eating properly
  - C. Not enough time off between training and athletic events
  - D. All of the above
  
3. Sleep deprivation can contribute to over training?
  - A. True
  - B. False
  
4. Only an athlete can over train?
  - A. True
  - B. False

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## Chapter 15

NEPT certified personal trainer manual

## Quizzes and Answer keys

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1. C
2. B
3. A
4. A
5. A
6. D

### CHAPTER 2

1. B
2. C
3. A
4. A
5. B
6. A
7. A
8. B

### CHAPTER 3

1. B
2. B
3. B
4. D
5. B
6. A
7. B
8. B
9. C

### CHAPTER 4

- 1.A
- 2.A
- 3.A
- 4.A
- 5.D
- 6.A
- 7.A
- 8.C
- 9.B
- 10.A
- 11.D
- 12.C
- 13.C
- 14.A
- 15.A
- 16.D
- 17.A

### CHAPTER 5

- 1.B
- 2.B
- 3.A
- 4.A
- 5.C
6. EGBCF
- 7.A
- 8.A
- 9.A

### CHAPTER 6

- 1.A,D, D, B, C, B
- 2.B
- 3.B
- 4.A
- 5.A
- 6.A
- 7.A
- 8.A

### CHAPTER 7

1. A
2. B
3. A
4. C
5. B
6. B
7. A
8. B
9. A
10. B
11. C

### CHAPTER 8

1. C
2. B
3. A
4. B
5. B
6. D
7. C
8. B
9. C
10. B
11. A
12. A
13. A

### CHAPTER 9

1. B
2. B
3. B
4. A
5. C



**CHAPTER 10**

1. A
2. A
3. A
4. C
5. B
6. B
7. D
8. B
9. B
10. A

**CHAPTER 11**

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2. A
3. B
4. D
5. C
6. A
7. D
8. D
9. A
10. B

**CHAPTER 12**

1. D
2. A
3. B
4. B
5. A

**CHAPTER 13**

1. B
2. C
3. B
4. B
5. C
6. A
7. A
8. D
9. B
10. C
11. A
12. D
13. A
14. D
15. C
16. B
17. B
18. D
19. B
20. A
21. B

**CHAPTER 14**

1. B
2. B
3. D
4. A
5. A
6. D
7. C
8. A
9. B
10. A
11. A
12. A
13. A
14. D
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16. B
17. A
18. A
19. D
20. A
21. A
22. B

**CHAPTER 15**

1. D
2. D
3. A
4. B

The test will ask questions about muscle attachments and function.  
We suggest the practice exams online at <http://winkingskull.com/navigation.aspx>

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