Lab 2
Muscle Analysis

Rubber Band Muscles

Learning Objectives

1. Learn the steps for analyzing the action of a hypothetical muscle using an example problem.
2. Analyze the actions of a series of hypothetical muscles in order to practice and gain an understanding of muscle analysis.
3. Determine the actions of a real muscle, teres major, using muscle analysis.
4. Collaborate with peers to demonstrate the steps of muscle analysis.

Why are we doing this?

You need to know what muscles do.

We want you to leave this class with a good working knowledge of the functional anatomy of the musculoskeletal system. Beyond just knowing the names and locations of muscles, you will need to know what muscles do, what a person will not be able to do with functional deficits in muscles, and how to use existing functions to compensate.

You could memorize all of the muscle actions, but it won't be meaningful and the knowledge won't last. In this course, we teach you to analyze muscle actions from a mechanical standpoint. Understanding this way of thinking about muscle actions will give you a strong foundation on which to base your continuing (continuous?) anatomical education. **This muscle analysis technique works for any muscle in any orientation at any joint.**

This method may seem hard at first. It won't be like other anatomy courses you've taken. You may not have had to think this way before. Take your time. Mastering this is worth the effort, and will make your anatomy knowledge more practically useful both in this class and, ultimately, in your career.

What will we do?

In this lab, we will use articulated skeletons and bones to examine how muscles move the bones that they are attached to. You'll see how to determine the action of a muscle around a given axis. Doing this in the lab with skeletons will give you a three-dimensional view of how these muscles function.

You'll work with your dissection groups and with instructors in small groups. Each group will be issued a rubber band! Use the skeletons and your own bodies to figure these actions out.

Take your time and think about the mechanics of the muscles. This is a learning *process*, and may take some time to sink in.

The mechanical method for analyzing muscle action uses a series of steps to determine the specific movement(s) produced by relating the pulls of the muscle to the axes of the joint being moved. Use the next page as a guide to each exercise.

Ask questions!!!!!!!!!!!!!!

Steps for Analyzing the Action of a Muscle

Use this for the whole lab.

1. What are the **attachments** of the muscle? Which is fixed? Which is movable?

2. Which **joint(s)** does a muscle cross? (If more than one, analyze each joint separately.) Around which **axis or axes** does the joint move? Which **planes** of movement are associated with the axes? Which **movements** are possible around these axes?

3. Based on the direction of the muscle's fibers, what is/are the possible **direction(s) of pull** of the muscle?

Muscles shorten when they contract and will pull the movable attachment <u>toward</u> the fixed attachment.

4. Where is the muscle **located relative to the axis** of the joint? Use the movable attachment to determine this orientation.

(A muscle can be located in two directions from an axis. For example, a muscle can be both inferior and anterior to an axis.)

5. Which **movement** is produced by the muscle around the axis of the given joint?

Use the movements possible for the axis in question to narrow your choices to two! Then use the direction of pull and the location of the muscle to determine the action.

Step 1: Muscle Attachments

Have one person in your group hold your rubber band between the *supraspinous fossa of the scapula* and the *head of the humerus*.
Those are your attachments.

You will have to know or figure out a muscle's attachments before you can analyze it.

Which attachment is fixed?

- By convention, for **muscles of the trunk**, the more inferior attachment is the fixed attachment; the more superior attachment is movable.
- For limb muscles, the more proximal attachment is fixed and the more distal attachment is movable. (We will make this more complicated later, but for now, stick with these conventions.)

In this example, the attachment to the scapula is fixed; the attachment to the humeral head is movable.

Step 2: Joint(s) Crossed by the Muscle

Look at your rubber band muscle. Start at its proximal attachment and follow the 'muscle' distally down the upper limb.

Name the joint(s) that you cross.

Just one joint is crossed:
The shoulder (glenohumeral) joint.

But if the rubber band muscle attached to the radius instead of the humeral head, which joints would it cross?

A muscle can move any joint that it crosses.

It may not have a major action at every joint that it crosses, but these minor actions can become important in rehab (to compensate for functional deficits in other muscles).

Step 2b: Axes of Movement at the Joint

How can the glenohumeral joint move?
It is a 'ball-&-socket' joint and can move around all 3 axes: transverse, anteroposterior (AP), and vertical.

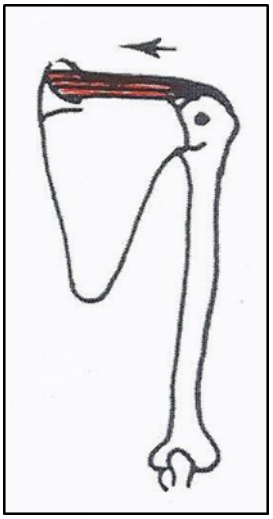
Only two movements are possible around each axis.		
Axis	**Plane of Movement**	**Possible Movements**
Transverse	Sagittal	Flexion Extension
Anteroposterior (AP)	Frontal (Coronal)	ADduction ABduction
Vertical	Horizontal (Transverse)	Medial Rotation Lateral Rotation

For the rubber band muscle, choose the **AP axis.**
Which two movements are possible around this axis?

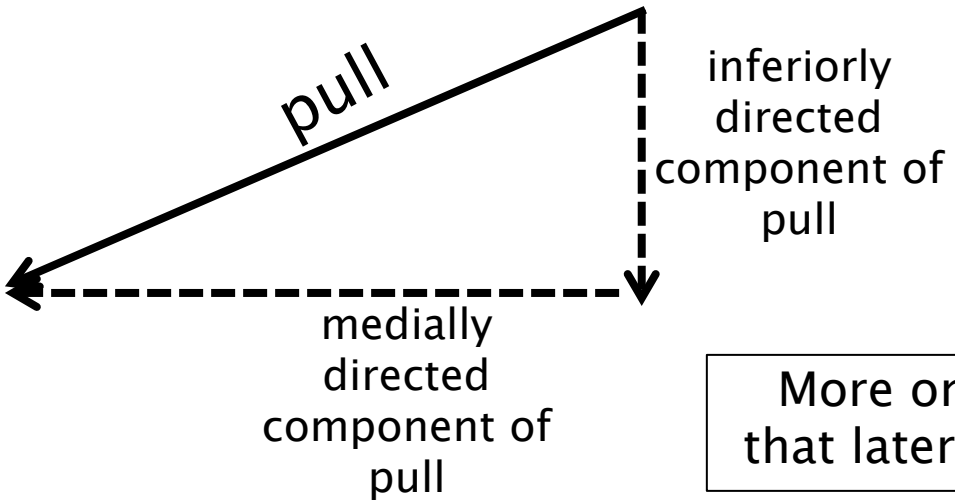
Step 3: Direction of Pull

Muscles shorten when they contract and will pull the movable attachment *toward* the fixed attachment.

*The rubber band muscle will pull the humeral attachment (movable) toward the scapula (fixed). The pull of the muscle is in the **medial direction.***



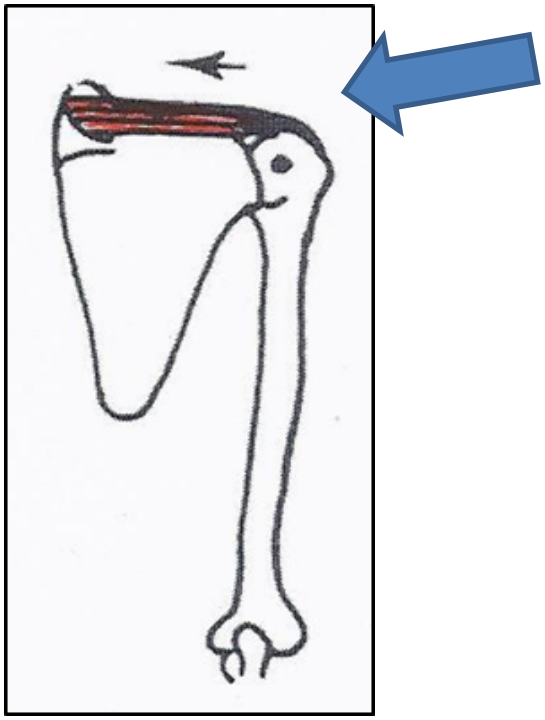
Most (real) muscles have an *oblique pull*. In that case, you need to break the pull into its horizontal and vertical components (vectors!). For example:



More on that later…

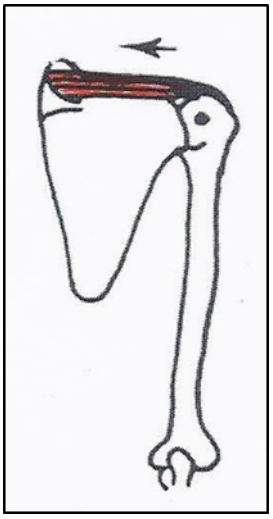
Step 4: Location of Muscle Relative to Axis

Where is the muscle in relation to the axis?
Describe where the rubber band is in relation to the AP axis. Look particularly at the movable attachment.



The muscle is
superior *to the AP axis!*
It is also ***lateral*** *to the AP axis.*

What We Have So Far



- *A muscle acting at the **glenohumeral joint.***
- We've chosen to analyze its action around the ***AP axis.***
- *The muscle **pulls in the medial direction** and is **superior & lateral to the AP axis.***

Some pull/location combinations have greater mechanical advantage than others and are better positioned to produce movement.

In this case, the **medial pull, superior to the AP axis** is far more effective than a medial pull lateral to the axis.

Step 5: Movements

Which movement is produced at this axis of the joint?

1. *Which movements are possible around the AP axis?*

ADduction or ABduction

2. *Using the rubber band to visualize the contraction and pull of the muscle,* ***how would a medial pull superior to the AP axis move the humerus?***

It would abduct the humerus.

Make more rubber band muscles.

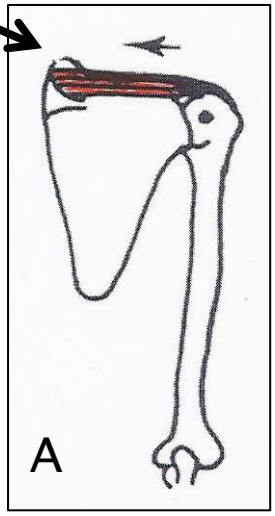
The next pages give you some ‘demonstration muscles’ to work with in order to solidify your understanding of this concept, using **other axes** and a **real muscle that acts around all 3 axes**.

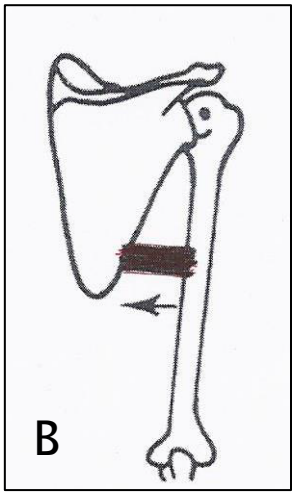
Use your rubber band!

Muscles that Act Around the Anteroposterior Axis of the Shoulder (Glenohumeral) Joint

You just did this one!

Posterior View of Right GH Joint
- *dot* = AP axis
- *arrow* = direction of pull of muscle





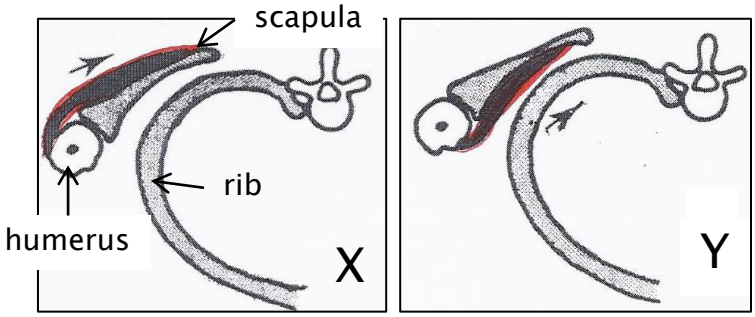
	Muscle A	Muscle B
Fixed Attachment		
Movable Attachment		
Direction of Pull		
Position Relative to AP Axis		
Movement Produced Around AP Axis		

Fill in this table.
Check your answers at the end of this packet.

Muscles that Act Around the Vertical Axis of the Shoulder (Glenohumeral) Joint

Horizontal Section through Right GH Joint

- *dot* = vertical axis
- *arrow* = direction of pull of muscle



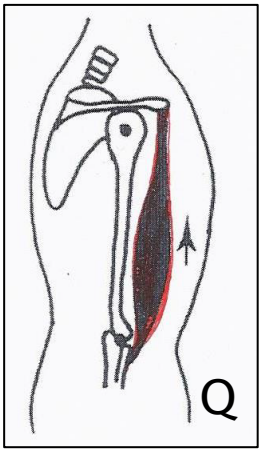
	Muscle X	Muscle Y
Fixed Attachment		
Movable Attachment		
Direction of Pull		
Position Relative to Vertical Axis		
Movement Produced Around Vertical Axis		

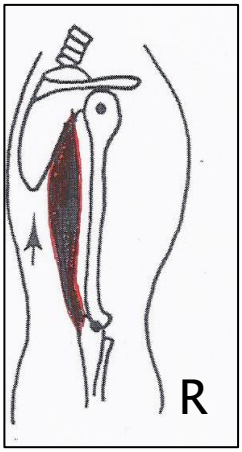
Look at the attachment to the humerus!

Fill in this table.
Check your answers at the end of this packet.

Muscles that Act Around the Transverse Axis of the Shoulder (Glenohumeral) Joint

Side View of Right GH Joint
- *dot* = transverse axis
- *arrow* = direction of pull of muscle

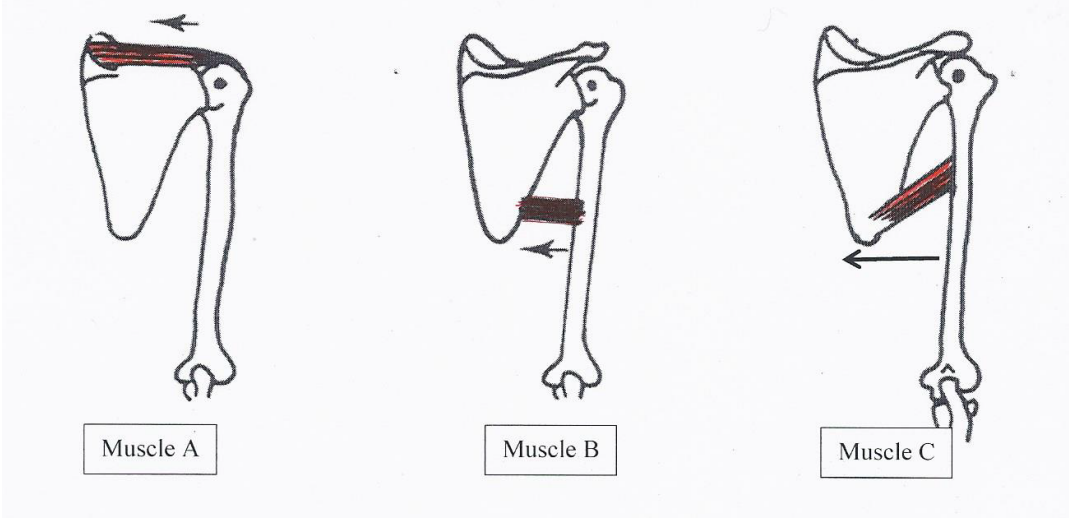




	Muscle Q	Muscle R
Fixed Attachment		
Movable Attachment		
Direction of Pull		
Position Relative to Transverse Axis		
Movement Produced Around Transverse Axis		

*These muscles also cross the **elbow**, with the same pull and position relative to its transverse axis.
What would the actions of these two muscles be around the transverse axis of the elbow?

General Principles



At any joint, two muscles with:
- **same** directions of pull, and
- **opposite** positions relative to the axis

will exert *opposing* movements at that joint.

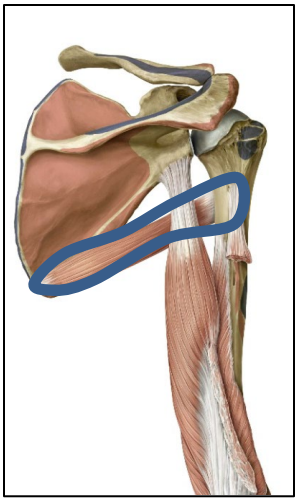
Muscles A & B both pull medially. Muscle A is superior to the AP axis & causes aBduction. Muscle B is inferior to the AP axis & causes aDduction.

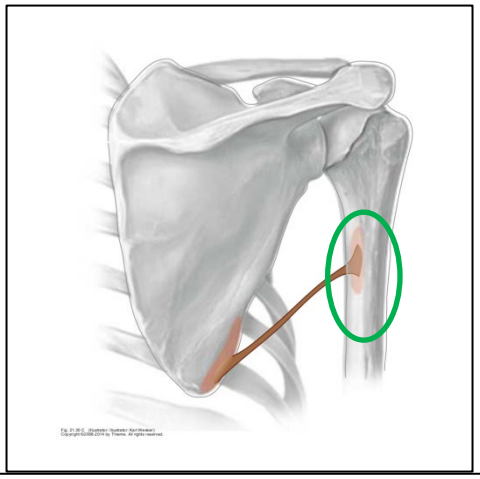
At any joint, two muscles with:
- **same** directions of pull, and
- **same** positions relative to the axis

will exert the *same* movement at that joint.

Muscles B & C both pull medially and are inferior to the AP axis. Both cause aDduction of the humerus.

Analyzing Teres Major (a real muscle)



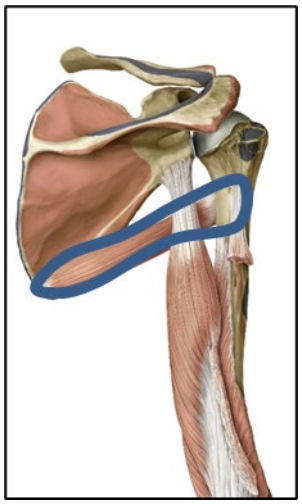


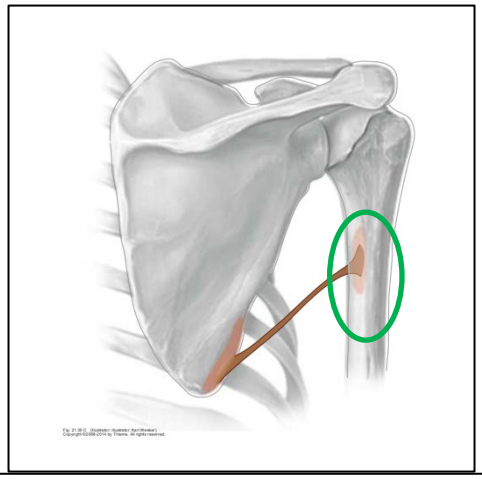
**attached to the *anterior* shaft of the humerus

	AP Axis	Transverse Axis	Vertical Axis
Fixed Attachment			
Movable Attachment			
Direction of Pull			
Position Relative to Axis			
Movement Produced Around Axis			

Try this muscle axis-by-axis.
Use worksheets on the next pages if you need to.

Teres Major (a real muscle)





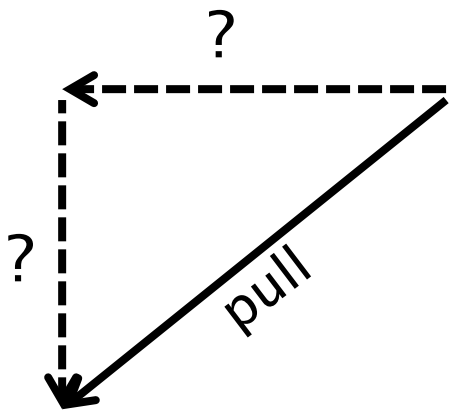
**attached to the anterior shaft of the humerus

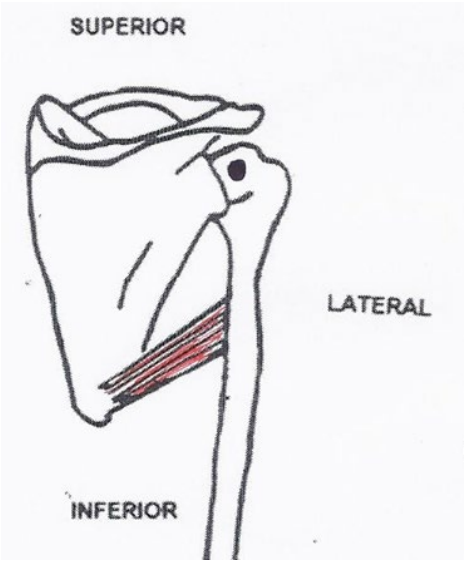
Most muscles have actions around multiple axes. You must **analyze each axis separately** to determine the actions of the muscle.

- If a muscle acts around 3 axes, it will have 3 actions; 2 axes, 2 actions; 1 axis, 1 action.

Work through the following tables to determine the action of **teres major** around each axis.
Use your rubber band!!

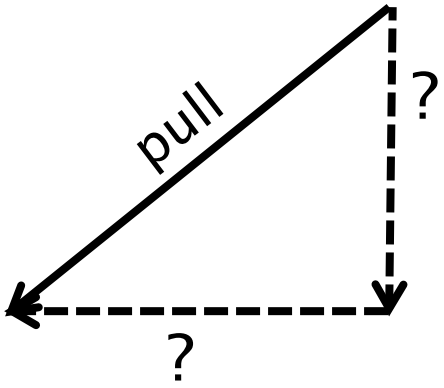
Teres Major – Anteroposterior Axis

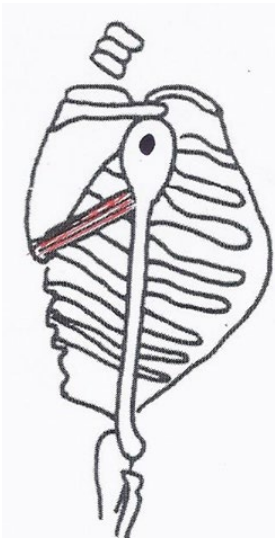




	AP Axis	
Fixed Attachment		The attachments are the same for all of the axes.
Movable Attachment		
Direction of Pull		The solid arrow (above) is the muscle's oblique pull. It is broken down into its two vectors: one in a _____direction and one in a _____ direction.
Position Relative to AP Axis		The muscle (& its movable attachment) is _____to the AP axis.
Movement Produced Around **AP Axis**		What are your choices??

Teres Major – Transverse Axis

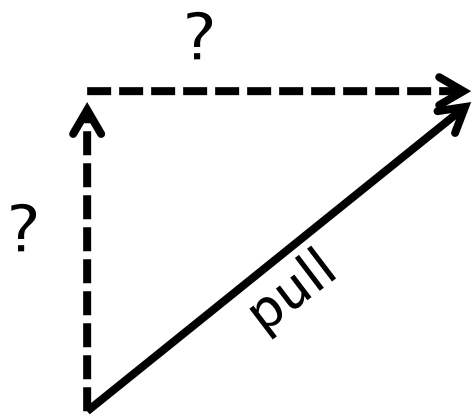


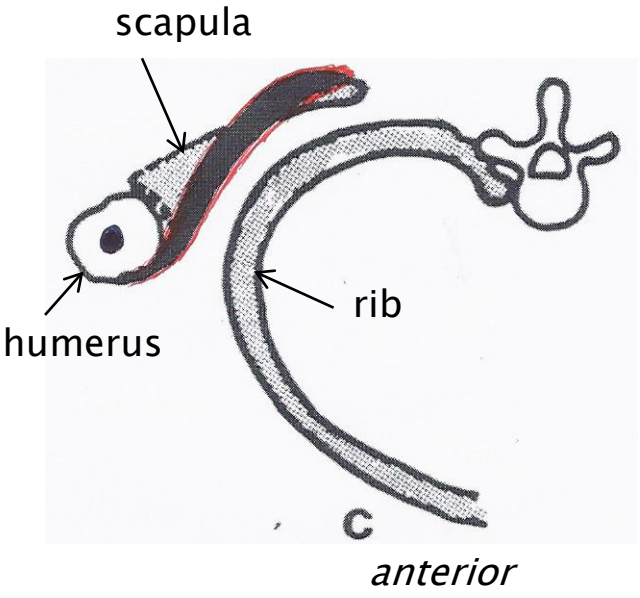


Teres major attaches to the **anterior** shaft of the humerus.

	Transverse Axis	
Fixed Attachment		The attachments are the same for all of the axes.
Movable Attachment		
Directions of Pull		The solid arrow (above) is the muscle's oblique pull. It is broken down into its two vectors: one in a _____direction and one in a _____ direction.
Position Relative to Transverse Axis		The muscle (& its movable attachment) is _____to the AP axis.
Movement Produced Around **Transverse Axis**		What are your choices??

Teres Major – Vertical Axis





anterior

	Vertical Axis	
Fixed Attachment		The attachments are the same for all of the axes.
Movable Attachment		
Direction of Pull		The solid arrow (above) is the muscle's oblique pull. It is broken down into its two vectors: one in a _____direction and one in a _____direction.
Position Relative to Vertical Axis		The MOVABLE ATTACHMENT of the muscle is _____to the vertical axis.
Movement Produced Around **Vertical Axis**		What are your choices??

Practice this!

You should understand this concept by the first exam.

Practice visualizing how the contraction (shortening) of muscles will pull on bones to move joints.

Put rubber band muscles across different joints in the trunk, upper limb, and lower limb.

- What will those muscles do?
- Which joint(s) do they cross?
- Which direction(s) do they pull relative to each axis of movement?
- What action(s) would that muscle perform?

Using a skeleton and a rubber band, demonstrate where to put a "muscle" that will:

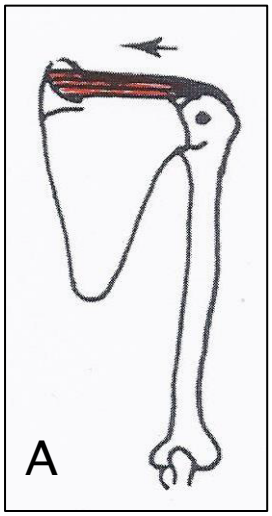
- flex the elbow
- pronate the forearm
- laterally bend of the trunk
- rotate the head to the opposite side
- extend the index finger
- medially / internally rotate the flexed knee
- abduct the wrist

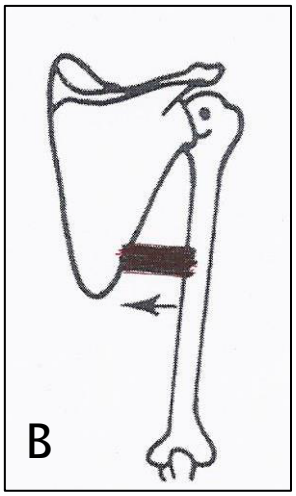
Please ask for help if you need it. This fundamental concept is easiest to teach/learn in the lab.

Solutions

Muscles that Act Around the Anteroposterior Axis of the Shoulder (Glenohumeral) Joint

Posterior View of Right GH Joint
- *dot* = AP axis
- *arrow* = direction of pull of muscle





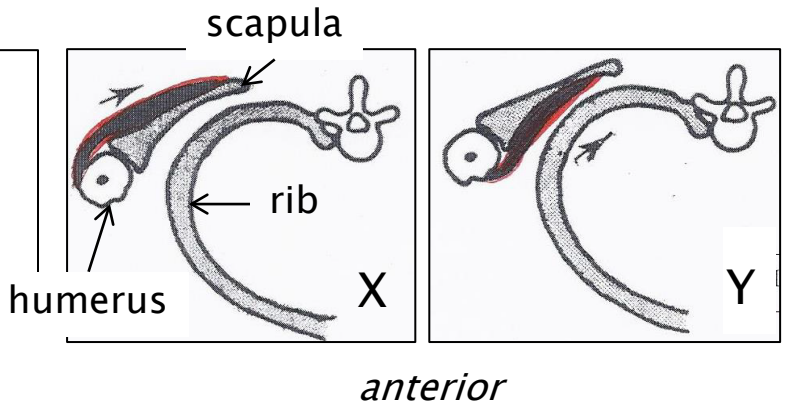
	Muscle A	Muscle B
Fixed Attachment	Scapula (supraspinous fossa)	Scapula (inferior part of lateral border)
Movable Attachment	Head of Humerus	Mid-shaft of Humerus
Direction of Pull	Medial ★	Medial ★
Position Relative to AP Axis	*Superior* ★	*Inferior* ★
Movement Produced Around AP Axis	**ABduction**	**ADduction**

★ Muscles with the *same direction of pull*, but *different positions* relative to the AP axis will have *opposite actions* around the axis.

Muscles that Act Around the Vertical Axis of the Shoulder (Glenohumeral) Joint

Horizontal Section through Right GH Joint

- *dot* = vertical axis
- *arrow* = direction of pull of muscle

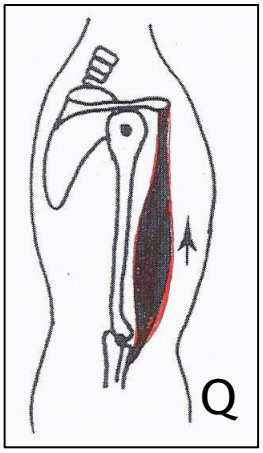


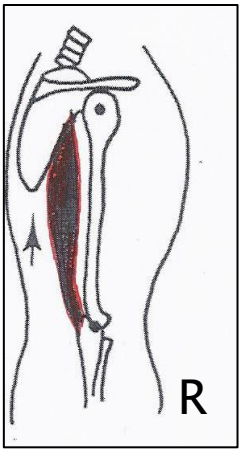
	Muscle X	Muscle Y
Fixed Attachment	Posterior Scapula	Anterior Scapula
Movable Attachment	Head of Humerus	Head of Humerus
Direction of Pull	Medial ★	Medial ★
Position Relative to Vertical Axis	*Posterior* ★	*Anterior* ★
Movement Produced Around Vertical Axis	**Lateral (External) Rotation**	**Medial (Internal) Rotation**

★ Muscles with the *same direction of pull*, but *different positions* relative to the vertical axis will have *opposite actions* around the axis.

Muscles that Act Around the Transverse Axis of the Shoulder (Glenohumeral) Joint

Side View of Right GH Joint
- *dot* = transverse axis
- *arrow* = direction of pull of muscle

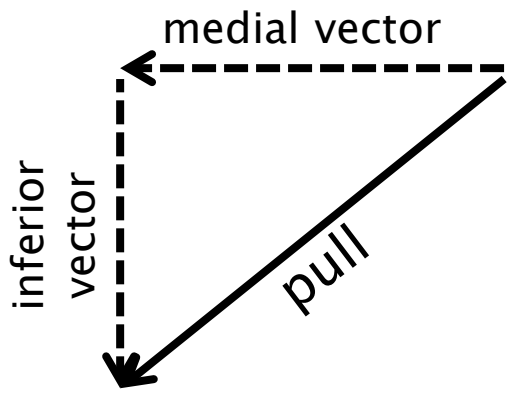


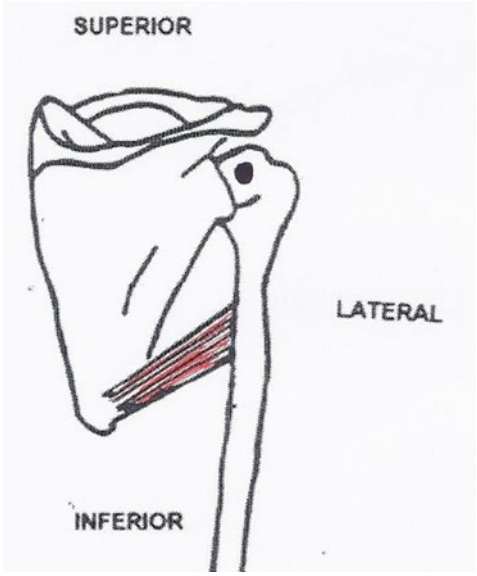


	Muscle Q	Muscle R
Fixed Attachment	Scapula	Scapula
Movable Attachment	Anterior Forearm (Radius)	Posterior Forearm (Ulna)
Direction of Pull	Superior	Superior
Position Relative to Vertical Axis	*Anterior*	*Posterior*
Movement Produced Around Vertical Axis	**Flexion of Humerus***	**Extension of Humerus***

*These muscles also cross the elbow, with the same pull and position relative to its transverse axis. So **Muscle Q also produces flexion of the elbow & Muscle R also produces extension of the elbow.**

Teres Major – Anteroposterior Axis



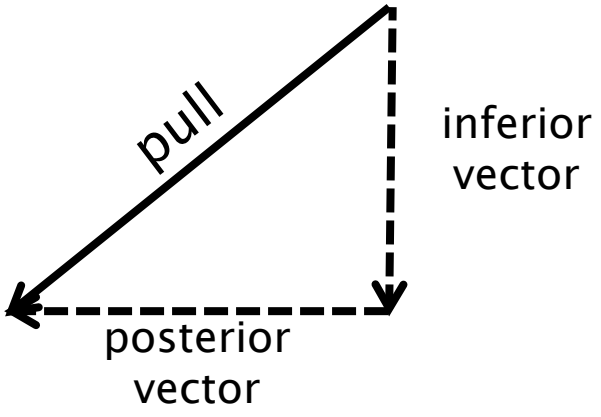


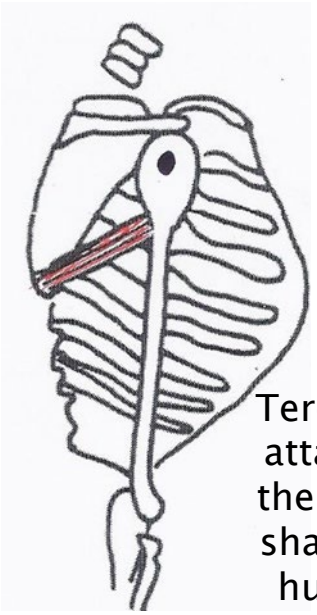
	AP Axis	
Fixed Attachment	Scapula (Inferior Angle)	The attachments are the same for all of the axes.
Movable Attachment	Anterior Humerus	
Direction of Pull	Medial & Inferior	The solid arrow (above) is the muscle's oblique pull. It is broken down to its two components: a medially-directed vector and an inferiorly-directed vector.
Position Relative to AP Axis	Inferior & Lateral	The muscle (& its movable attachment) is inferior to the AP axis.
Movement Produced Around **AP Axis**	**ADduction of Humerus***	A medial (or inferior) pull inferior (or lateral) to the AP axis will pull the humerus toward the body.

*__Both__ combinations of pull & position cause ADduction:

- a medial pull inferior to the AP axis
- an inferior pull lateral to the AP axis

Teres Major – Transverse Axis

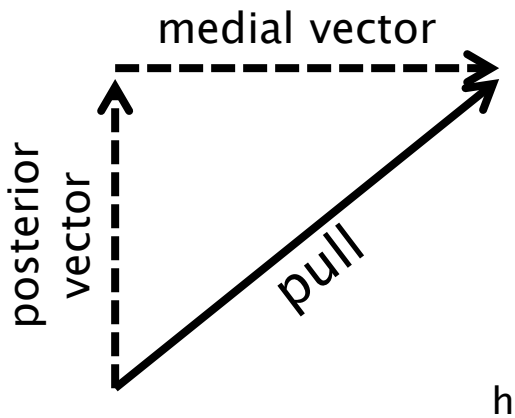


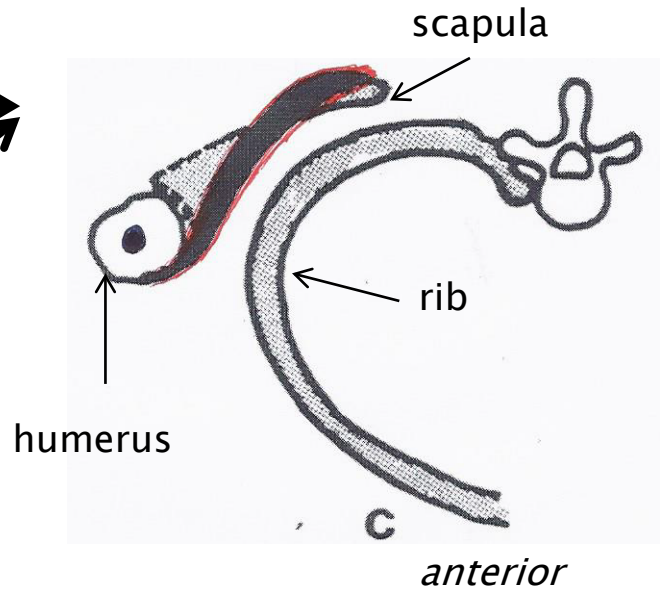


Teres major attaches to the **anterior** shaft of the humerus.

	Transverse Axis	
Fixed Attachment	Scapula (Inferior Angle)	The attachments are the same for all of the axes.
Movable Attachment	Anterior Humerus	
Directions of Pull	Posterior & Inferior	The solid arrow (above) is the muscle's oblique pull. It is broken down to its two components: an inferiorly-directed vector and a posteriorly-directed vector.
Position Relative to Transverse Axis	Inferior & Anterior	The muscle (& its movable attachment) is inferior & anterior to the AP axis.
Movement Produced Around **Transverse Axis**	**Extension of Humerus**	A posterior pull inferior to the axis will pull the humerus backward around the transverse axis (in the sagittal plane). (The other pull—inferior pull anterior to the axis – is less powerful from the anatomical position, but works well from a flexed position.)

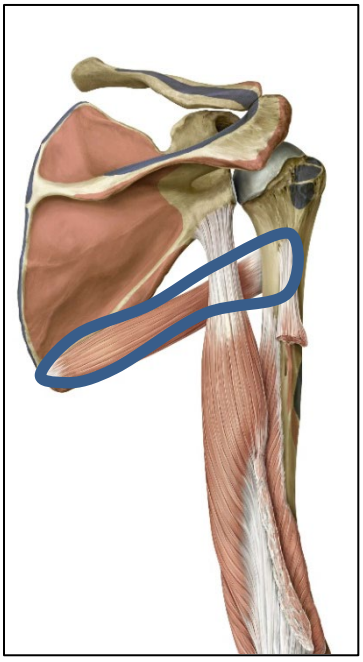
Teres Major – Vertical Axis

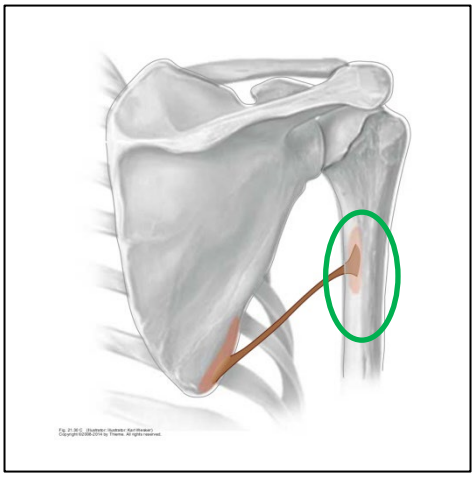




	Vertical Axis	
Fixed Attachment	Scapula (Inferior Angle)	The attachments are the same for all of the axes.
Movable Attachment	Anterior Humerus	
Direction of Pull	Posterior & Medial	The solid arrow (above) is the muscle's oblique pull. It is broken down to its two components: a posteriorly-directed vector and a medially-directed vector.
Position Relative to Vertical Axis	Anterior	The muscle's movable attachment is anterior to the vertical axis.
Movement Produced Around Vertical Axis	**Medial (Internal) Rotation**	A medial (or posterior) pull anterior to the vertical axis will pull the anterior shaft of the humerus medially in rotation.

Teres Major (a real muscle)





**attached to the anterior shaft of the humerus

	AP Axis	Transverse Axis	Vertical Axis
Fixed Attachment	Scapula (Inferior Angle)		
Movable Attachment	Anterior Shaft of Humerus		
Directions of Pull	Medial & Inferior	Posterior & Inferior	Posterior & Medial
Position Relative to Axis	Inferior & Lateral	Inferior & Anterior	Anterior
Movement Produced Around Axis	**ADduction of Humerus**	**Extension of Humerus**	**Medial (Internal) Rotation of Humerus**