Recognizing the Importance of Lower Trapezius Strength and Function

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Disclosures

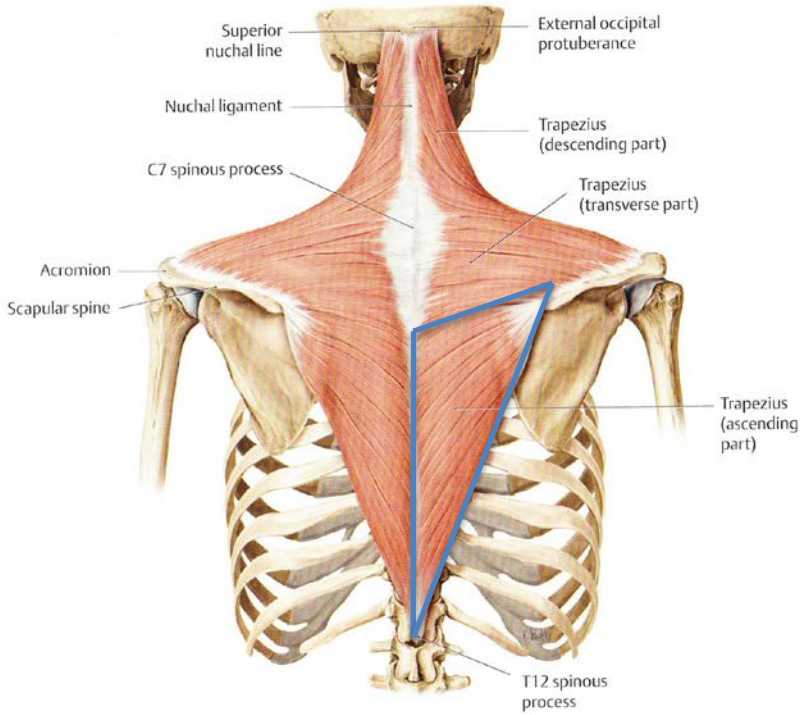
- I have no actual or potential conflicts of interest to disclose with regard to the contents of this presentation

Goals

- Brief anatomy review
- Scapulothoracic function with focus on the role of the lower trapezius
- Dysfunction of the lower trapezius
- Treatment considerations

Anatomy - Trapezius

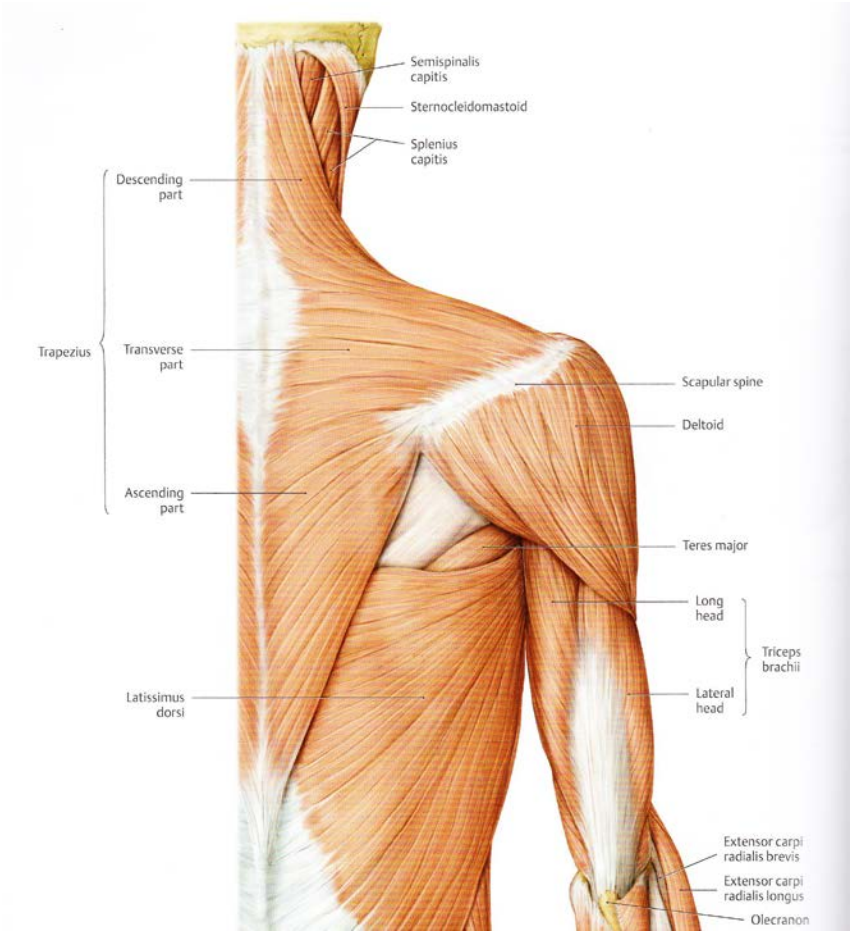
- Origin
  - Medial one third of nuchal line
  - External occipital protuberance
  - Ligamentum nuchae
  - Spinous processes of C7-T12
  - Supraspinous ligament
- Insertion
  - Lateral one third of the clavicle
  - Medial aspect of the acromion
  - Scapular spine
  - Tubercle just lateral to medial border of scapular spine
- Innervation
  - Spinal accessory nerve, C3, C4

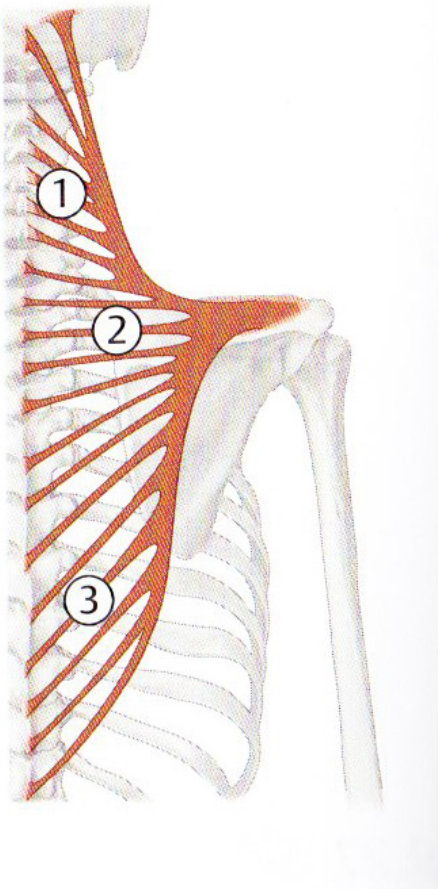


Thieme Atlas of Anatomy

Hobart et al, 2008

Anatomy





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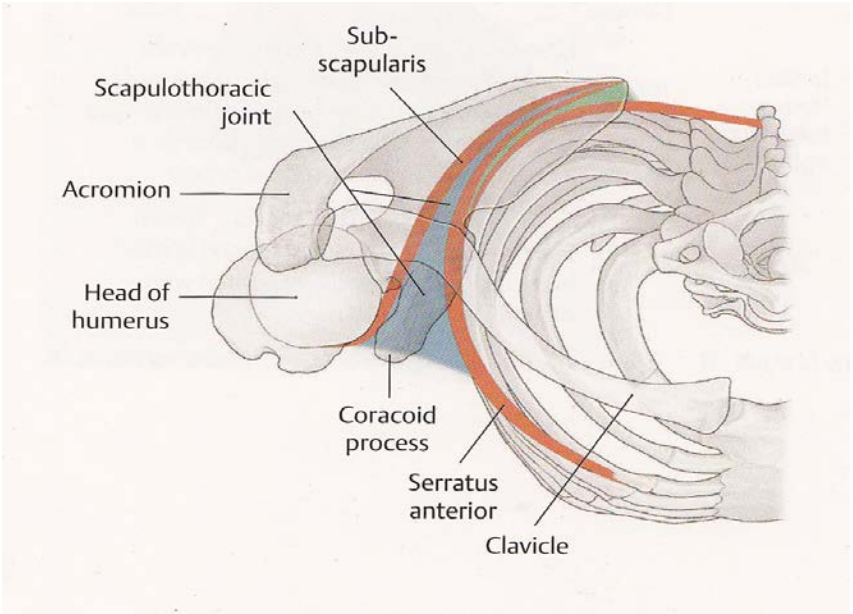
Anatomy – Scapulothoracic "Joint"



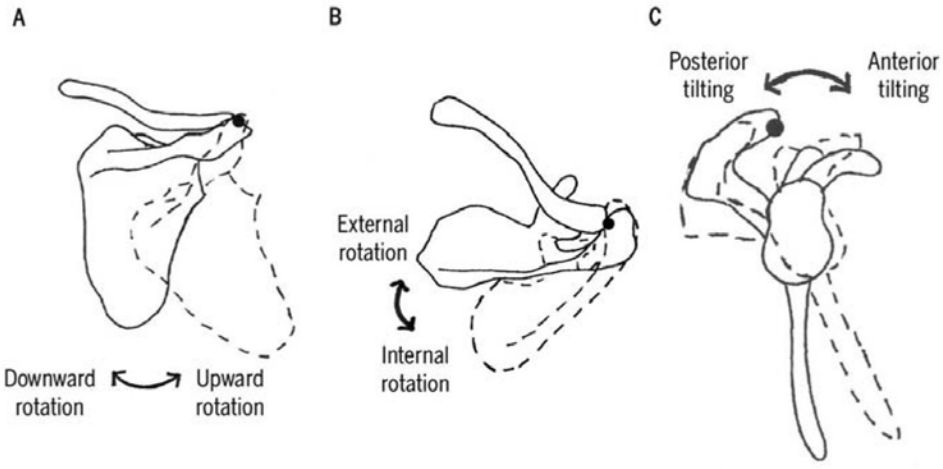
Thieme Atlas of Anatomy

- Pseudoarticulation
- Indirect connection to axial skeleton via clavicular articulations
- Resting position with respect to thorax
  - Slight upward rotation
  - ~30-45 degrees internal rotation
  - ~5-20 degrees anterior tilting

Dutton, 2004

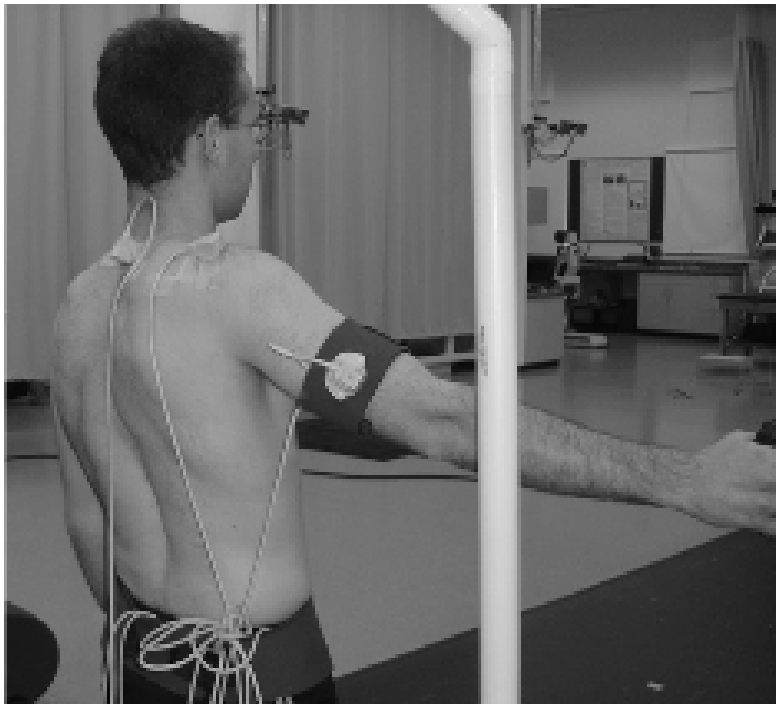
Scapulothoracic Motion

- Scapulothoracic motion
  - Frontal plane
    - Upward and downward rotation (U/DROT)
  - Sagittal plane
    - Anterior and posterior tilting
  - Transverse plane
    - Internal and external rotation (I/EROT)
- All motions multiplanar given orientation of scapula on thorax
  - Protraction/Retraction



Ludewig and Reynolds, 2009

Scapulothoracic Motion

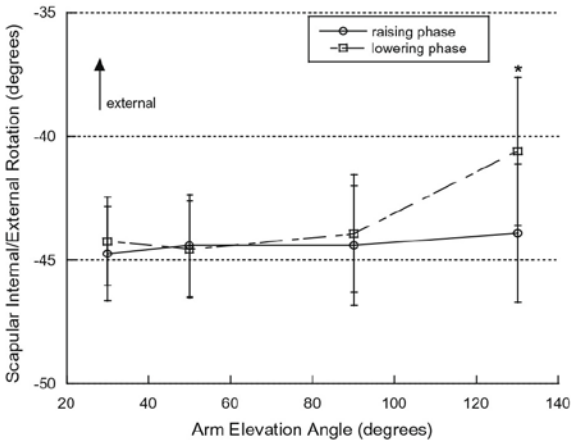


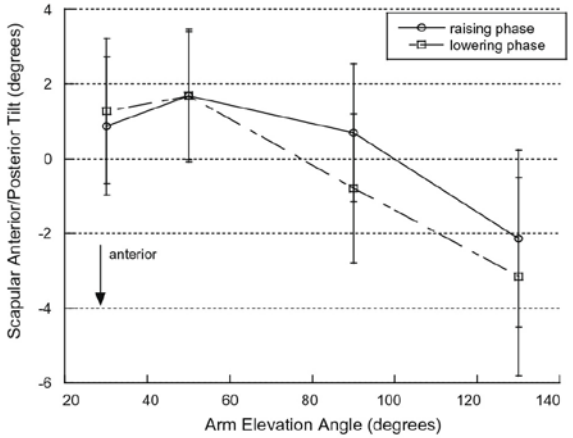
Laudner et al, 2006

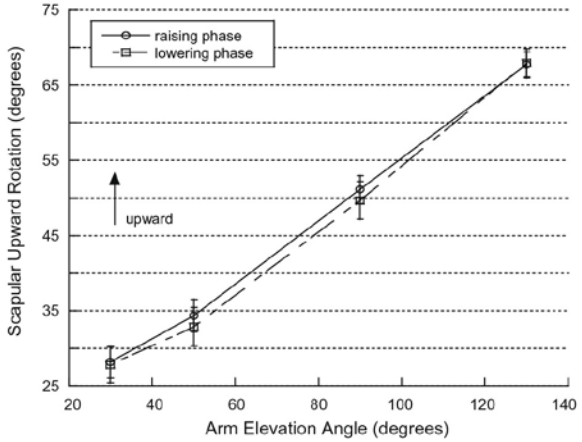
- Most consistent scapular kinematic findings with elevation
  - UROT throughout elevation
- Variability in the literature
  - Tilting
  - I/EROT
- Generally accepted
  - Posterior tilting
  - EROT

Ludewig and Reynolds, 2009
Ebaugh and Spinelli, 2010

Scapulothoracic Motion







- Scaption from supported sitting
  - Raising and lowering
  - Kinematics and EMG

Ebaugh and Spinelli, 2010

Scapula

- Functions of the scapula in the overhead athlete
  - Stable base for glenohumeral joint (GHJ)
  - Retract/Protract through the motion
  - Rotate the acromion to allow clearance
  - Base for muscle attachment
  - Transfer kinetic energy from the trunk to the upper extremity
- Most commonly discussed with regard to throwing
  - Reaching
  - Lifting
  - Weight-bearing
  - Swinging
- In summary – provide dynamically stable platform for upper extremity function

Kibler, 1998

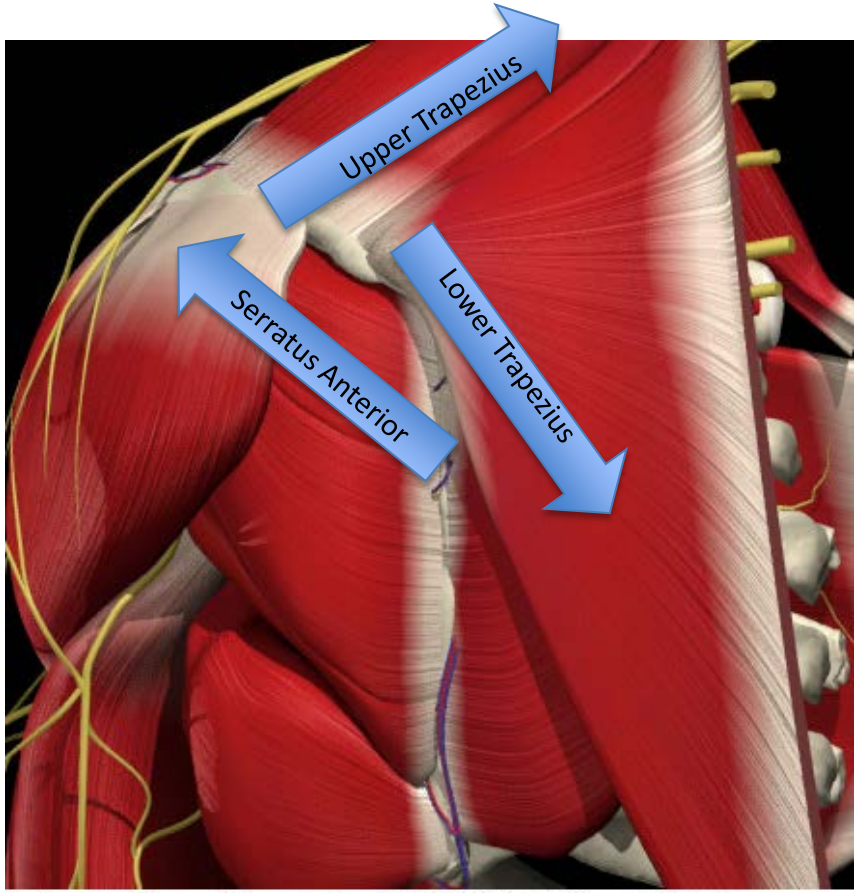
Trapezius - Function

- Upper fibers (UT)
  - UROT
  - Elevation
- Middle fibers (MT)
  - Adduction (Retraction)
- Lower fibers (LT)
  - UROT
  - Depression

- Not so straightforward
  - Complex interaction between different fibers, other musculature
  - Different roles depending upon position
  - Mobility and stability function

Function – Force Couple for Upward Rotation

- Coordinated contraction
  - Synergistic UROT
  - Antagonistic elevation/depression
  - Results in dynamically fixed axis for UROT
- Do not forget
  - MT
  - Posterior rotator cuff
  - Pectoralis minor…



Interactive Shoulder © 2000 Primal Pictures Ltd.

Borsa et al, 2008.

Function - Throwing

Table I. Shoulder activity by muscle and phase during baseball pitching[a] (adapted from DiGiovine et al.,[2] with permission)

Muscles	No. of subjects	Phase					
		wind-up[b] (% MVIC)	stride[c] (% MVIC)	arm cocking[d] (% MVIC)	arm acceleration[e] (% MVIC)	arm deceleration[f] (% MVIC)	follow-through[g] (% MVIC)
Scapular							
Upper trapezius	11	18±16	64±53	37±29	69±31	53±22	14±12
Middle trapezius	11	7±5	43±22	51±24	71±32	35±17	15±14
Lower trapezius	13	13±12	39±30	38±29	76±55	78±33	25±15
Serratus anterior (6th rib)	11	14±13	44±35	69±32	60±53	51±30	32±18
Serratus anterior (4th rib)	10	20±20	40±22	106±56	50±46	34±7	41±24
Rhomboids	11	7±8	35±24	41±26	71±35	45±28	14±20
Levator scapulae	11	6±5	35±14	72±54	76±28	33±16	14±13
Glenohumeral							
Anterior deltoid	16	15±12	40±20	28±30	27±19	47±34	21±16
Middle deltoid	14	9±8	44±19	12±17	36±22	59±19	16±13
Posterior deltoid	18	6±5	42±26	28±27	68±66	60±28	13±11
Supraspinatus	16	13±12	60±31	49±29	51±46	39±43	10±9
Infraspinatus	16	11±9	30±18	74±34	31±28	37±20	20±16
Teres minor	12	5±6	23±15	71±42	54±50	84±52	25±21
Subscapularis (lower 3rd)	11	7±9	26±22	62±19	56±31	41±23	25±18
Subscapularis (upper 3rd)	11	7±8	37±26	99±55	115±82	60±36	16±15
Pectoralis major	14	6±6	11±13	56±27	54±24	29±18	31±21
Latissimus dorsi	13	12±10	33±33	50±37	88±53	59±35	24±18
Triceps brachii	13	4±6	17±17	37±32	89±40	54±23	22±18
Biceps brachii	18	8±9	22±14	26±20	20±16	44±32	16±14

a Data are given as means and standard deviations, and expressed for each muscle as a percentage of an MVIC.

b From initial movement to maximum knee lift of stride leg.

c From maximum knee lift of stride leg to when lead foot of stride leg initially contacts the ground.

d From when lead foot of stride leg initially contacts the ground to maximum shoulder external rotation.

e From maximum shoulder external rotation to ball release.

f From ball release to maximum shoulder internal rotation.

g From maximum shoulder internal rotation to maximum shoulder horizontal adduction.

MVIC = maximum voluntary isometric contraction.

Escamilla and Andrews, 2009
DiGiovine et al, 1992

Function - Throwing

- Stride phase
  - Scapular stabilization
  - Upward rotation for GHJ position for abduction
- Cocking phase
  - Scapular stabilization
  - Retraction for GHJ position for horizontal abduction and EROT
- Acceleration
  - Scapular stabilization
    - Base for rapidly rotating humeral head
- Deceleration
  - Eccentrically control scapular elevation, rotation, protraction

Escamilla and Andrews, 2009

Function – Golf Swing

Table VIII. Scapular activity by muscle and phase during the golf swing[a] (adapted from Kao et al.,[45] with permission)

Muscles	No. of subjects	Phase				
		take-away (% MVIC)	forward swing (% MVIC)	acceleration (% MVIC)	deceleration (% MVIC)	follow-through (% MVIC)
Levator scapulae	15					
Trail arm		29±19	38±39	34±41	12±12	4±4
Lead arm		5±3	42±20	62±46	39±26	29±24
Rhomboids	15					
Trail arm		30±18	46±27	32±24	21±12	5±4
Lead arm		7±13	68±27	57±46	26±26	30±33
Upper trapezius	15					
Trail arm		24±14	4±4	13±20	23±19	5±6
Lead arm		5±4	29±26	42±50	34±29	27±18
Middle trapezius	15					
Trail arm		37±12	18±24	19±26	26±21	12±15
Lead arm		3±3	51±26	36±21	21±18	28±20
Lower trapezius	15					
Trail arm		52±28	17±12	16±28	22±22	10±15
Lead arm		7±10	49±27	37±28	20±16	35±18
Upper serratus anterior	15					
Trail arm		6±4	58±39	69±29	52±18	40±14
Lead arm		30±15	20±29	31±31	31±18	21±13
Lower serratus anterior	15					
Trail arm		9±5	29±17	51±33	47±25	40±18
Lead arm		27±11	20±21	21±24	29±20	29±21

a Data are given as means and standard deviations, and expressed for each muscle as a percentage of an MVIC.

MVIC = maximum voluntary isometric contraction.

Escamilla and Andrews, 2009
Kao et al, 1995

Function – Golf Swing

- Take-Away
  - Trail arm upward rotation and elevation for GHJ positioning
- Forward Swing
  - Lead arm retraction and stabilization
- Acceleration, deceleration, follow-through
  - Lead arm stabilization (relatively low activity)

Escamilla and Andrews, 2009

Dysfunction

- Can go wrong many ways
  - Weakness
  - Postural deviation
  - Pain inhibition
  - Muscular imbalance
  - Combination of any of the above
- Consequences
  - Force couple disruption
  - Altered length/tension relationships
  - Inability to fulfill scapular roles

Dysfunctional Motion - Dyskinesis

- Impingement/Rotator Cuff Pathology
  - 9 studies evaluating UROT
    - 4 decreased
    - 1 increased
    - 4 no difference
  - 7 studies evaluating posterior tilting
    - 4 decreased
    - 2 increased
    - 1 no difference
- Multidirectional GHJ instability
  - 4 studies evaluating UROT
    - 4/4 decreased
- Shoulder stiffness (GHJ elevation)
  - 3 studies evaluating UROT
    - 3/3 increased

Ludewig and Reynolds, 2009

Dysfunctional Muscle Activity

- Cools et al 2004
  - 19 overhead athletes with impingement side:side comparison
  - Peak force and EMG activity during isokinetic protraction/retraction

- Significant findings
  - Lower peak protraction force at high velocity
  - Lower protraction/retraction force ratio at low velocity
  - Lower LT EMG activity during retraction at high velocity

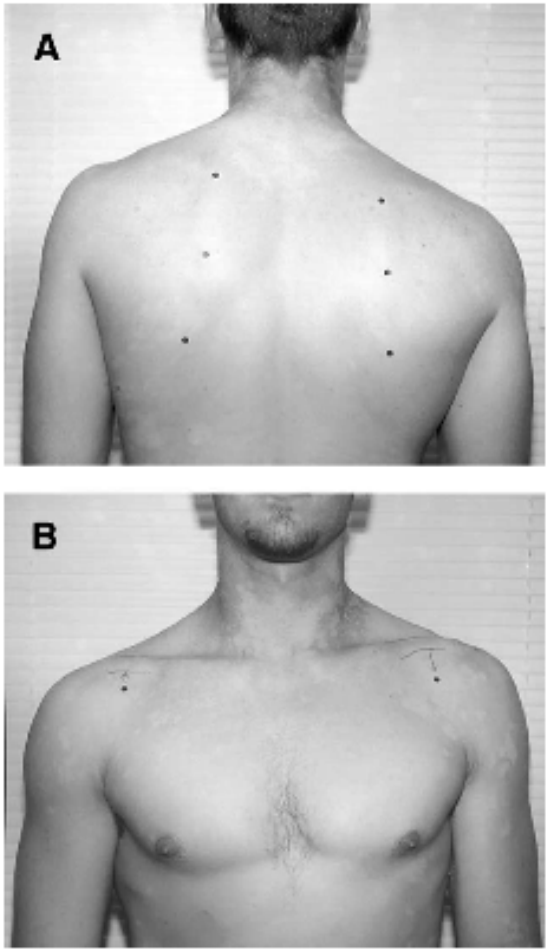
Dysfunctional Muscle Activity

- Cools et al 2007
  - 39 overhead athletes with impingement and 30 healthy controls
  - EMG activity and intramuscular trapezius ratios during isokinetic abduction, isokinetic EROT
- Significant findings
  - Higher UT EMG activity both motions
  - Lower LT EMG activity abduction
  - Lower MT EMG activity EROT
  - Altered UT/MT, UT/LT ratios

Dysfunctional Muscle Activity

- Huang et al, 2015
  - 82 subjects with shoulder pain
  - Classified dyskinesis observationally into three categories
  - EMG activity and kinematics during scaption

- Significant results
  - Lower LT activity in those with inferior angle and medial border prominence during lowering
  - Higher UT activity in those with inferior angle and medial border prominence throughout



Burkhart et al, 2003

Dysfunction

- Good evidence for changes with pathology
  - Scapular dyskinesis
  - Altered muscular activity
    - Changes in overall activity
    - Changes in inter and intramuscular firing ratios
- Questions remain
  - Factors in etiology of pathology?
  - Compensatory mechanisms secondary to pathology?
  - Representative of pain inhibition?
  - What to do about it?

Treatment - Lower Trapezius

- Increasing % MVIC
  - Low row
  - Robbery
  - D1 flexion
  - Unilateral row
  - Scaption <80
  - Scaption > 120
  - Prone horizontal abduction with EROT (T)
  - Prone EROT at 90 abduction
  - Prone flexion at 135 abduction (Y)

Uhl, 2009

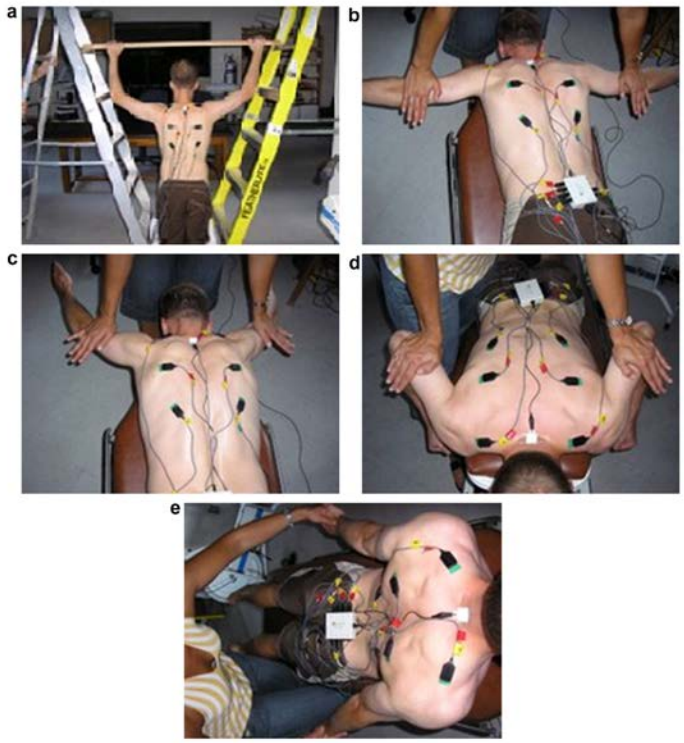
Treatment – Lower Trapezius

Figure 2. Low row exercise.

Figure 4. Robbery exercise.

Kennedy et al, 2009

Treatment – Lower Trapezius



- Arlotta et al, 2011
  - 18 healthy subjects
  - EMG during 5 isometric exercises
  - Assessed amplitude and intramuscular ratio
- Significant findings
  - Modified prone cobra and prone row most favorable when considering amplitude and isolation

Arlotta et al, 2011

Treatment – Scapular Muscle Balance

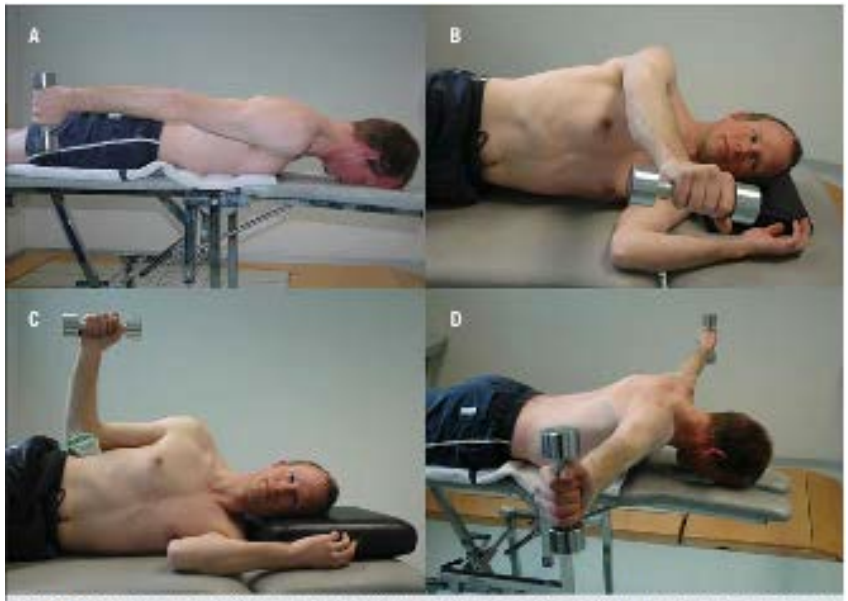


FIGURE 1. Exercises studied: (1) prone extension, (2) forward flexion in side lying, (3) external rotation in side lying, and (4) prone horizontal abduction with external rotation.

- Clinically often identify imbalance with UT activity greater than middle and lower fibers
- Cools et al, 2007
  - High ratio of LT and MT activity relative to UT
    - Prone extension
    - Sidelying elevation
    - Sidelying EROT
    - Prone horizontal abduction with EROT

De Mey et al, 2009

Treatment – Progression

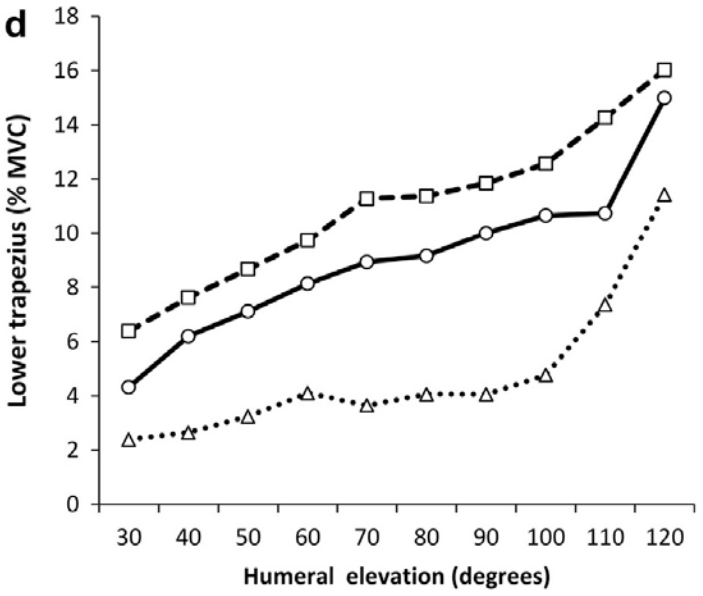
Figure 3. Lawnmower exercise, with weight.

- Transition to functional motions that are specific to the athletic activity
  - Incorporate “Kinetic Chain” components
    - Regional interdependence
    - Proximal influences
    - Scapular role in energy transfer
- LT is not just a stabilizer
  - Strength
  - Power

Kennedy et al, 2009

Treatment - Progression

- Functional motions
  - Diagonals
  - Rotation
  - Chop
  - Simulated throwing/serving
- Trunk rotation does impact firing patterns
  - Facilitation of muscle activity
  - Specificity of training



Nagai et al, 2013

In Closing

- Lower trapezius function vital in supporting the role of the scapula
- Body of evidence demonstrating altered scapular kinematics and altered activity of the scapular musculature with pathology
- Wealth of research to assist in the selection of strengthening tasks to target scapular musculature

TSM Towson Sports Medicine

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Thank You!

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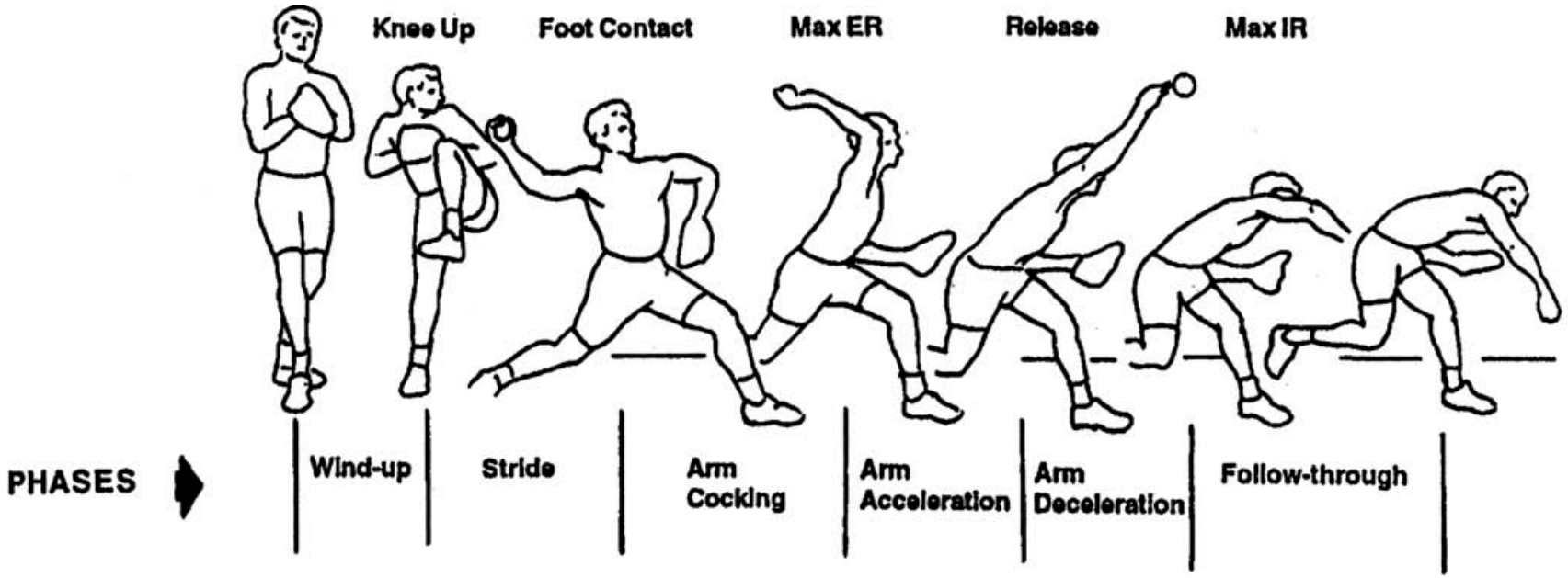
Phases of Pitching



Fleisig et al, 2006

Phases of the Golf Swing

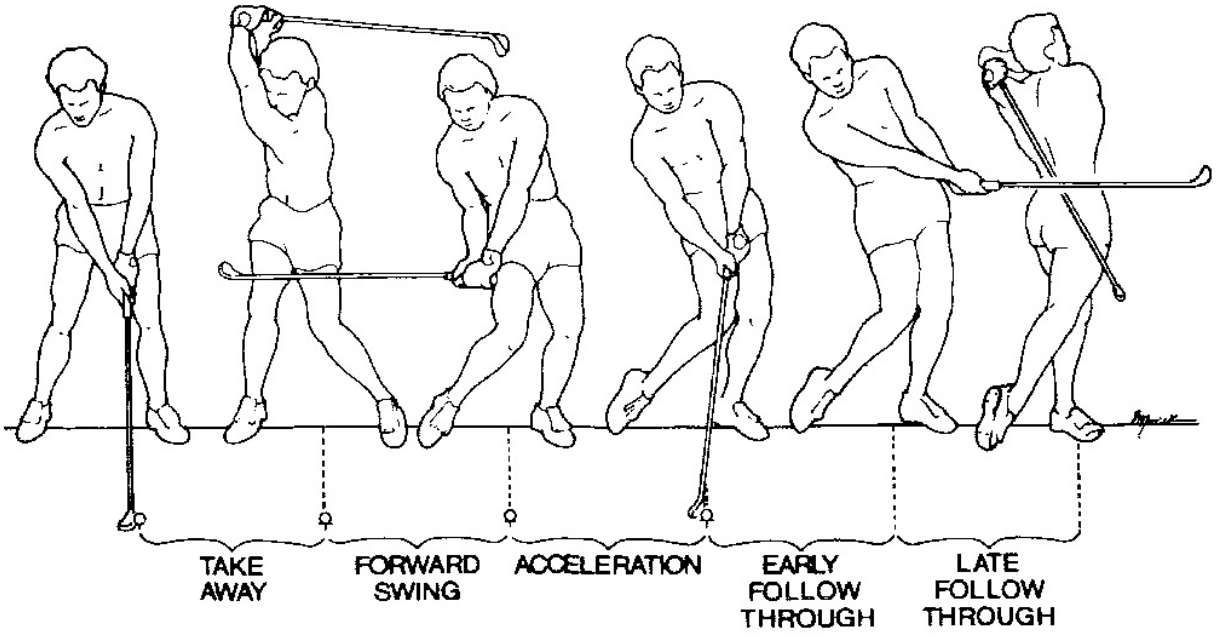


Figure 1. Phases of the golf swing. (Reprinted with permission.[6])