Hinge Theory!

Gina Pongetti, MPT, MA, CSCS, ART-Cert.
Physical Therapist and Biomechanics Specialist
Co-owner and Director: Achieve Orthopedic Rehabilitation Institute Sports Medicine, IL
www.achieveorthosports.com
Owner- MedGym.net
Gina.pongetti@gmail.com

Dr. Holly Benjamin, MD, FACSM
Vice President- ACSM 2016-18
Professor of Pediatrics and Orthopedic Surgery
Director- Primary Care Sports Medicine
University of Chicago, Chicago, IL
www.uchospitals.edu
hbenjami@peds.bsd.uchicago.edu

Disclosure

- The following speakers of this CME activity have no relevant financial relationship with commercial interests to disclose and will not discuss any unapproved or off-label products:
  - Holly J. Benjamin, MD, FACSM
  - Gina Pongetti Angeletti, MPT, MA, CSCS, ART-Cert.

Objectives

1. Define the Hinge Theory

1. Review biomechanics, arthrokinematics, and anatomy of the spine, shoulders and hips

1. Identify spine injury predispositions with relation to performing arts medicine

1. Teach a hands-on and visual spine and movement assessment

Differential Diagnosis: Common Causes

- Spinal Overload Syndrome
  - Pars fracture (spondylolysis)
  - Spondylogenic LBP
  - Hyperlordotic mechanical LBP
  - Facet joint dysfunction
- Other serious causes of LBP

Back

Vertebral Endplate (8-12 yrs.)
(Scheuermann's)

↓

Post Elements (12-18 yrs.)
(Spondylolysis)

↓

Disc Herniation (25-50 yrs.)

↓

Degen. Disc/DJD (50+)

Epidemiology

- Sands et al. (2003).

  A Cross sectional analysis showed that at any time, actively (not necessarily in treatment) spondy category injuries or pre-spondy were at times close to 17-32% of analyzed elites, national or Olympic athletes

  There is no collected mass data on shoulder and hip injuries specifically

History

- Started in classroom at Marquette in school with 1999 Kinesiology course with Don Neumann (Author of infamous Kines Textbook
- Theory began in clinic, between both locations, treating over 250 spondy-category injuries or facet dysfunction, case study published
- Began to realize that fractures are often not caused from hypermobility (hyperflexible children, excessive available range of motion, which the public is often worried about)
- To the contrary- simultaneous symptoms were often noted of lack of shoulder flexion and hip extension, when grossly measured in clinic

So… what is it?

- Knowledge of the etiology of injury combined with treatment (what works and what doesn't)
- Perfecting the mix between mobility and stability
- Understanding the arthrokinematics of the spine, shoulders and hips as well as sacrum in combination to create the total motion of the "Arch"

When to Focus on Flexibility?

- At risk athletes can be identified as early as age 7
- This is when assessment protocols should be instituted and are most effective
- Assessment early allows for opportunity of application of stretching protocols in order to make objective improvements

- Sermeev (1966) showed that the largest levels of improvement occur starting at the age of 7 through the age of 11, maxing out at the age of 15. The study involved 3,000 children.

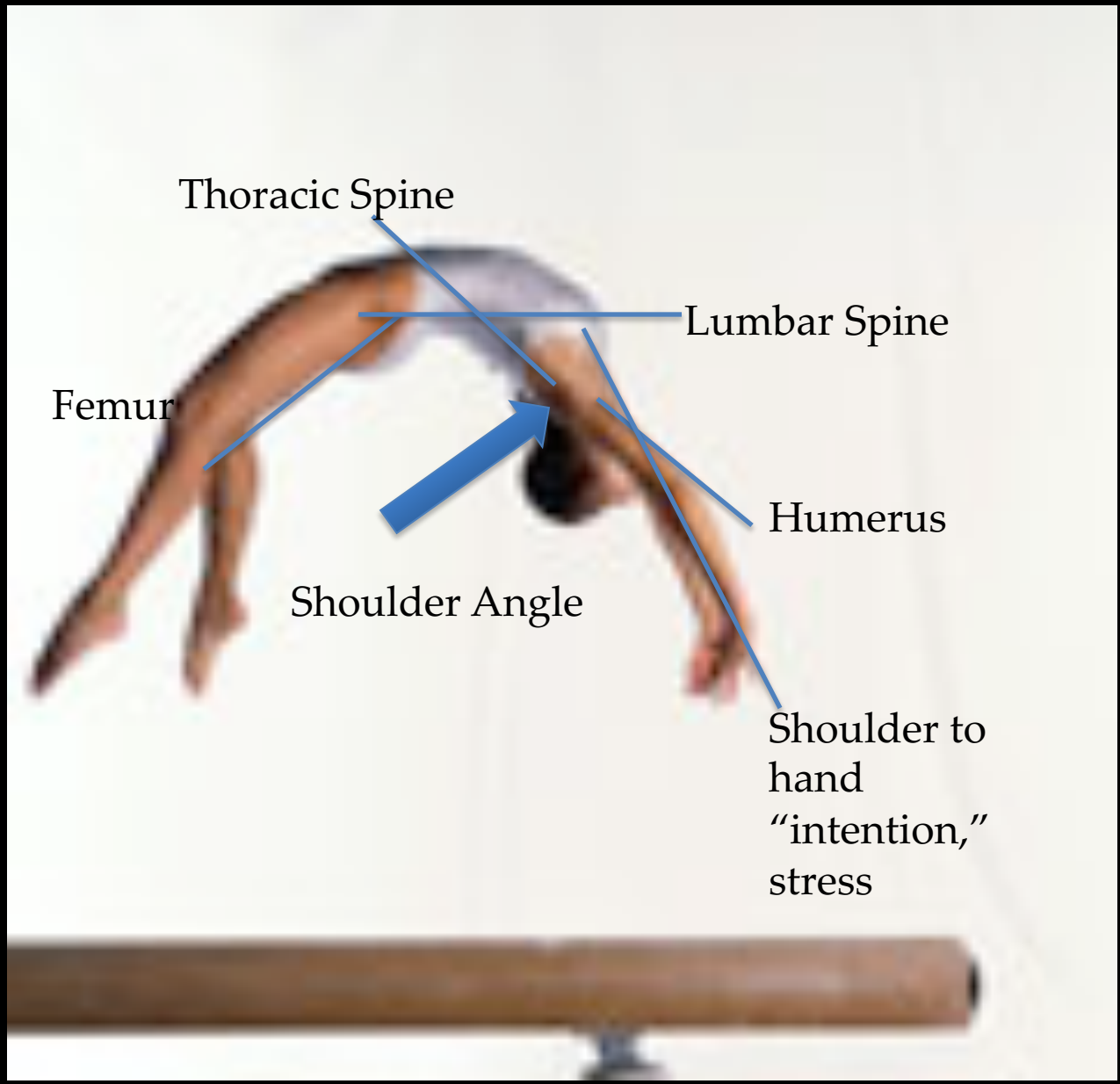
Three-Joint Flexibility

- Sermeev (1966): There was a trend that within the ages of 12-15, shoulder, knee and hip flexibility decreased over this period of time
  - Puberty
  - Estrogen, testosterone
  - Muscle development
  - Height/growth
  - Skill development

State of Mind

3 parts to an arch (in gross motion terms)

1. Shoulder opening (anatomical flexion)
2. Back bending, or lordosing
3. Hip opening (or anatomical hip extension)

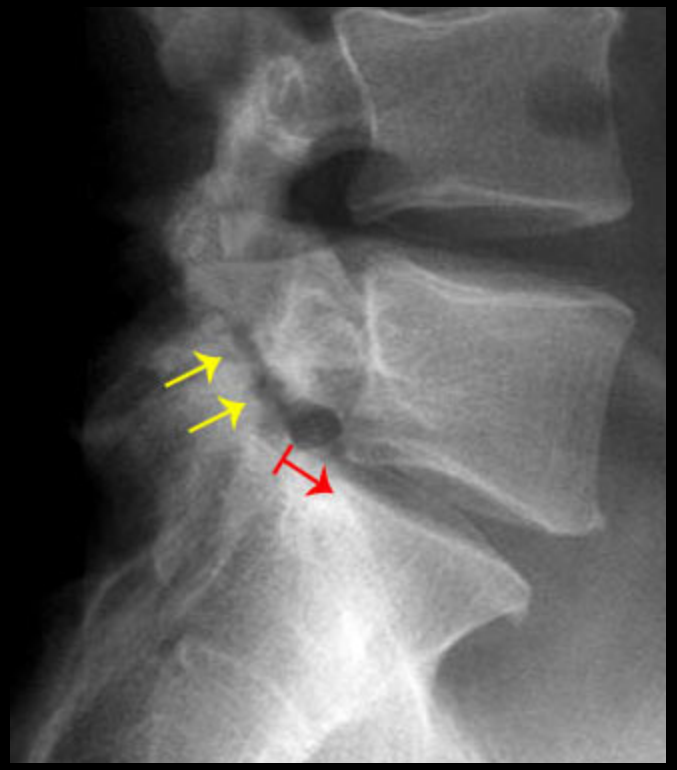


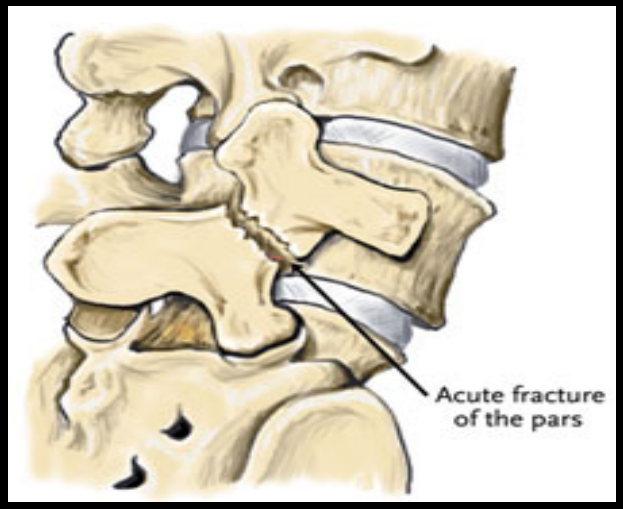
Pictures of hinging, external

Natural resting arch/lordosis

Flat above, flat below

Imaging: Radiographs (AP, lat, obliques)





Sensitivity: 30-40%)

Arch to flat?

Excessive hinge, can you find it? (Remember…T spine = min Ext

Lack of Ability to reverse curvature from anatomical predisposition to lumbar lordosis to kyphosis (flexion)

10-20^0 lordosis => ⇧ stress from 50-75% BW

(Hamill and Knutzen 1995)

Hinge Theory

- Shoulder flexibility
- Hip flexibility
- Assessment
- Significance to other sports??

JOINT BREAK DOWN

1) Shoulder

2) Hip

3) Spine

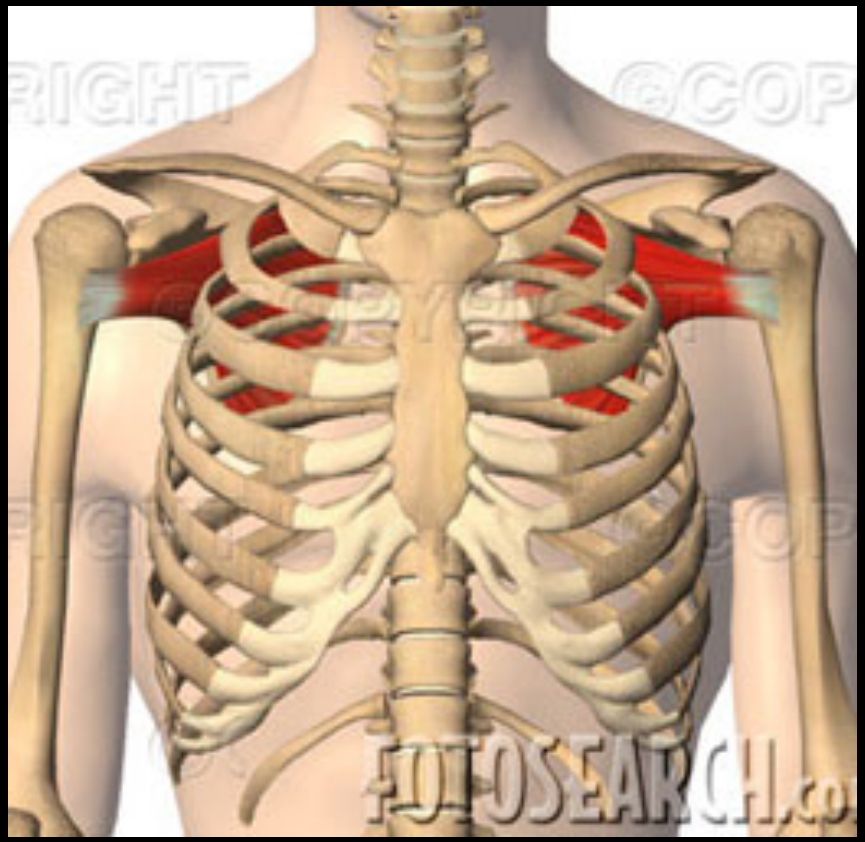
Shoulder Anatomy and Explanation

- When raising your arms overhead, many things are stretched:
  - Abs
  - Lats
  - Pecs (some fibers)
  - Triceps
  - Intercostal muscles
  - Shoulder capsule
- Limitations in above may lead to hinging

Shoulder Anatomy

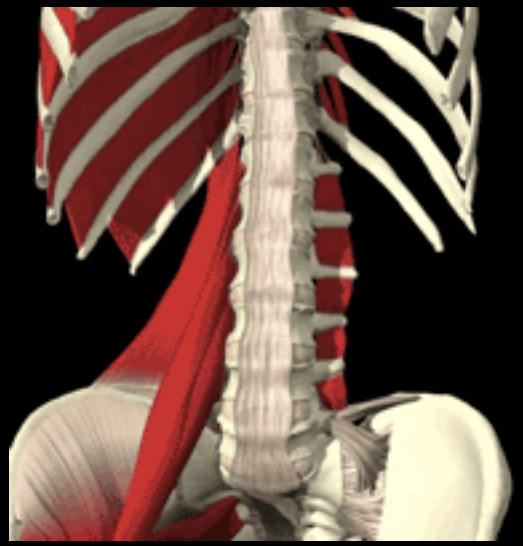
Subscapularis

Pecs



Hip Anatomy

- When extending the hip, many things are stretched:
  - Abs
  - Psoas
  - Iliacus
  - Rectus femoris
  - Sartorius
  - Other fascia and hip flexors



Iliopsoas
Common Culprit: Flexibility Inhibitor

- Hip flexor
- Tilts the hips anteriorly
- Arches/lordoses the back
- Prevents reversal of lordosis when tight
- Needs to stretch in split position
- Attaches at T12-L5
  - Anterior bodies, parts of disc, and TPs

Example - HIPS

- Hips:
  - The more flexibility in the capsule and anterior musculature, the more the hip can work without the lower back arching, or jamming, and without the hips turning out, or externally rotating

Look familiar? NO hip flexibility- flat as a board!

Example- Hips/Split

Should be unable to see right (far) ASIS from opposite side lateral view

Example- Hips - leaps

- Look at turn out of back leg and “hinge” in back (evident in leo crease, too)
- Rotation is compensation for lack of back leg hip flexor flexibility, leads to hinging

3) SPINE

- Thoracic
- Lumbar
- Facets
- Sacrum
  - Flexion = Nutation
  - Extension = Counternutation
  - Axis!
    - Left Diagonal, Right Diagonal
    - Important in relative “split” position (Next..)

Anatomy- Spine

Articulating Facets

(Fitt 1996, p. 69)

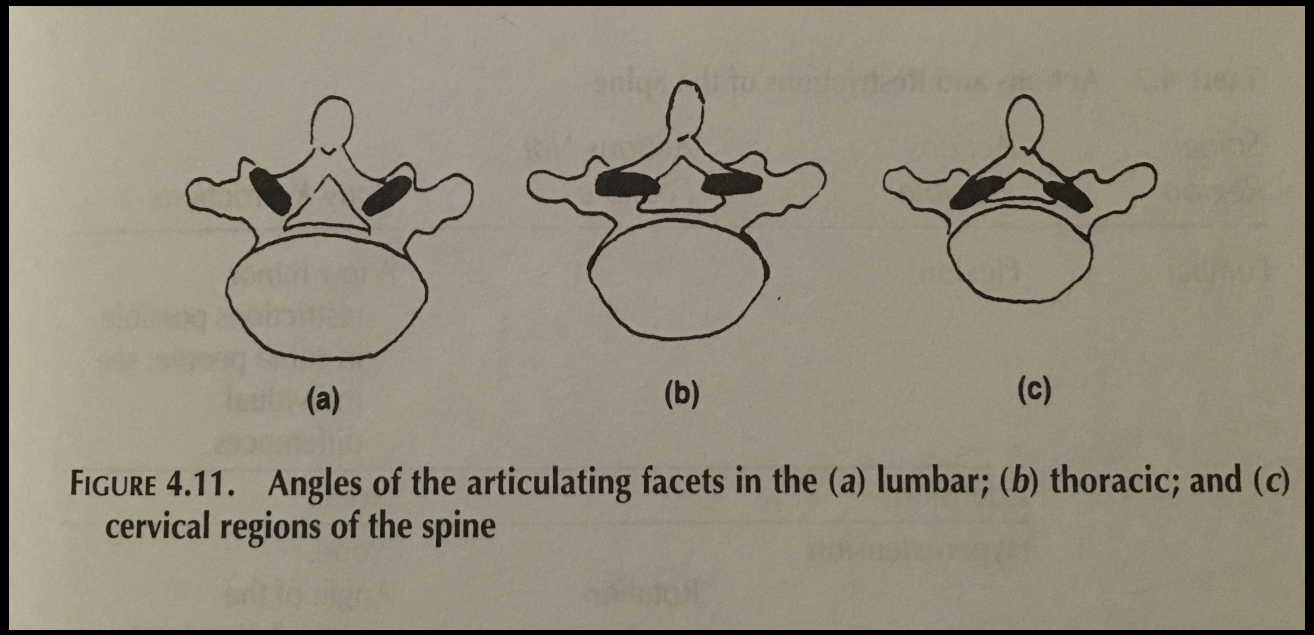


FIGURE 4.11. Angles of the articulating facets in the (*a*) lumbar; (*b*) thoracic; and (*c*) cervical regions of the spine

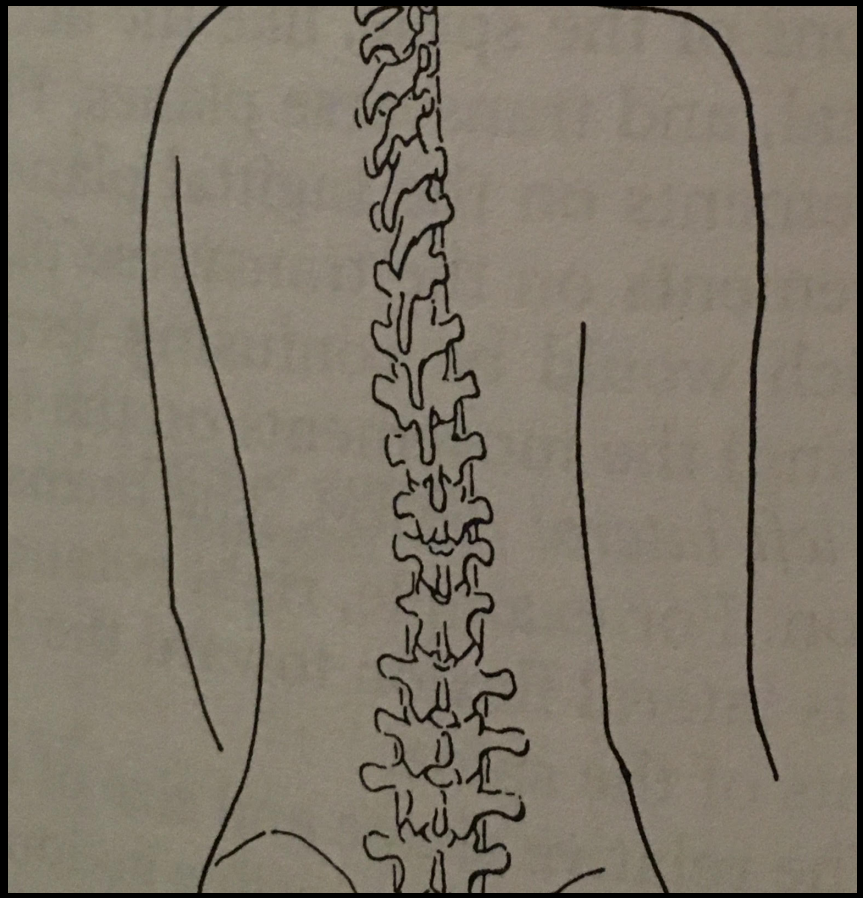
- Lumbar- 45 degrees M to L, A to P
- Thoracic- M to L neutral angle
- Cervical- approx 45 degrees L to M, A to P

Anatomy- spine

Rotation

- Free in cervical
- Free in Thoracic (SB demands a decent amount of combination of rotation to avoid rib contact rib-to-rib)
- Almost negligible in L spine
  - (Note: Extension and HE of the L spine no restrictions, however, rotation is…)

Picture (Fitt 1996, p. 68)



Side bending flat as well, all locked up

Left SB

Right SB

The Forgotten Sacrum

- (Clippinger 2007, p. 95)
  - Sacrum tilts anteriorly an average of 30deg
  - Necessary for full range of lordosis of the lumbar spine

- Very rarely do coaches understand this 4th "piece" of the curves of the spine and its relative importance to lordosis available movement capability and attainment of end ranges

Compensations

- If the low back is not flexible, joint above and joint below can help
  - Thoracic spine
  - Hips
- If the upper back is not flexible, joints can help as well
  - Lower back
  - Shoulders
- Extra: joint compensation – elbow stress, predisposition to OCD/Panners

Spine Functional Anatomy

- When the spine is lordosed, the following happens:
  - Facet joints close down
  - Abs are stretched
  - Hip flexors are stretched (lumber and sacral)
  - Muscles can work to get the spine there
  - If too much of an angle, you can have approximation, touching, or jamming (never good!) of the spinous processes

Square with the use of mats to raise body, un-”arch” the back, and square the hips to as high as the athlete needs- MEASURE angle between two femurs (thighs)

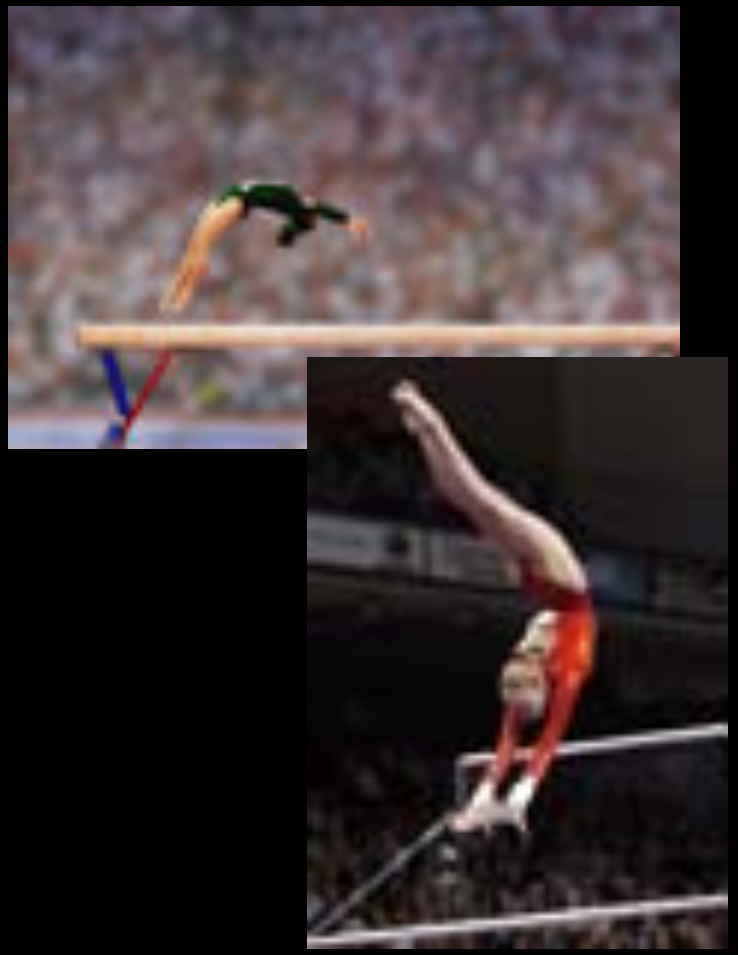
- Kids will tell you that they have Left and Right splits fully to ground
- Odds are… they do not with ASIS perpendicular to legs
- Assume that unless square = THEY ARE LIKELY ALL HINGING!

Pictures & Measurement

- Take picture of athlete doing a back bend
- Measure the shoulder and hip angles, and record
- Feet must be flat
- Knees must be straight
- Elbows must be locked out

Functional assessment

- Try to take pics in action, and still frame, or video so that you can still frame the exact moment!



Spine Arthokinematics

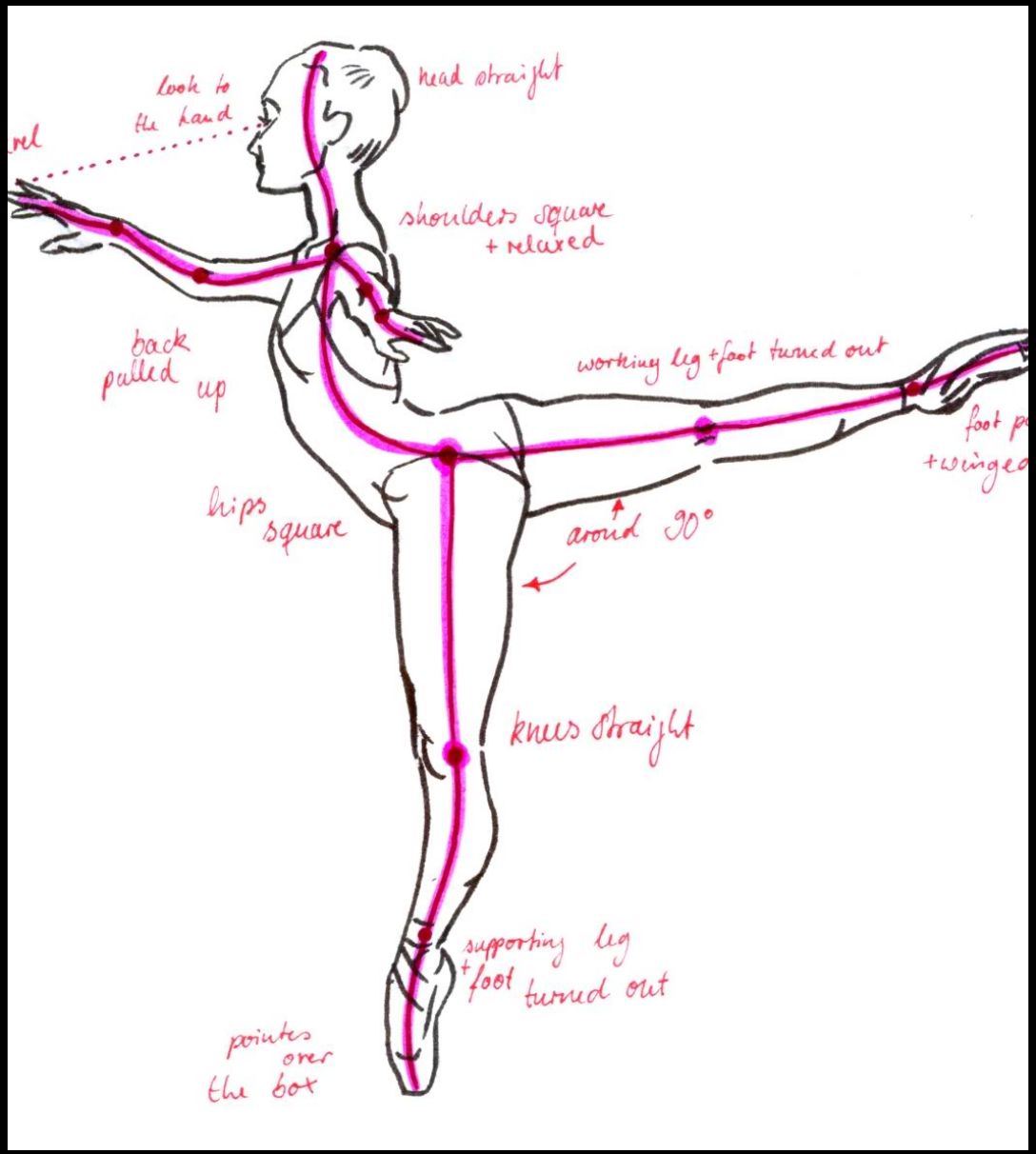
- Lumbar spine rotation has been cited as being very limited (Fitt 1996). The guidance to limitations of motion in the lumbar spine are directly related to anatomy
- Flexion and extension are easily allowed (sagittal plane)
- Lateral flexion is also allowed (left and right SB)
- Most “rotation” that one will see in the lower spine (think split position) occurs relatively in the femur ER, hyperextension of the spine, and iluim shifting
- “the inferior articulating facets fitting inside the angle of the superior articulating facets of the vertebra below limit most rotation in the lumbar region (p. 67)

Skill assessment: Developmental

- Let's discuss: Gymnastics
  - Arching over a swiss ball
  - Starring "bridging" on floor
  - Moving to standing back bend
    - Need ab muscles to eccentrically lower and stand up
  - Kickover
    - Sheer forces if not balanced in strength
  - Backhandspring
  - Layout in the air (back or front flipping)
  - Layout on beam, stepped out (uneven distribution of force)
  - Double layouts

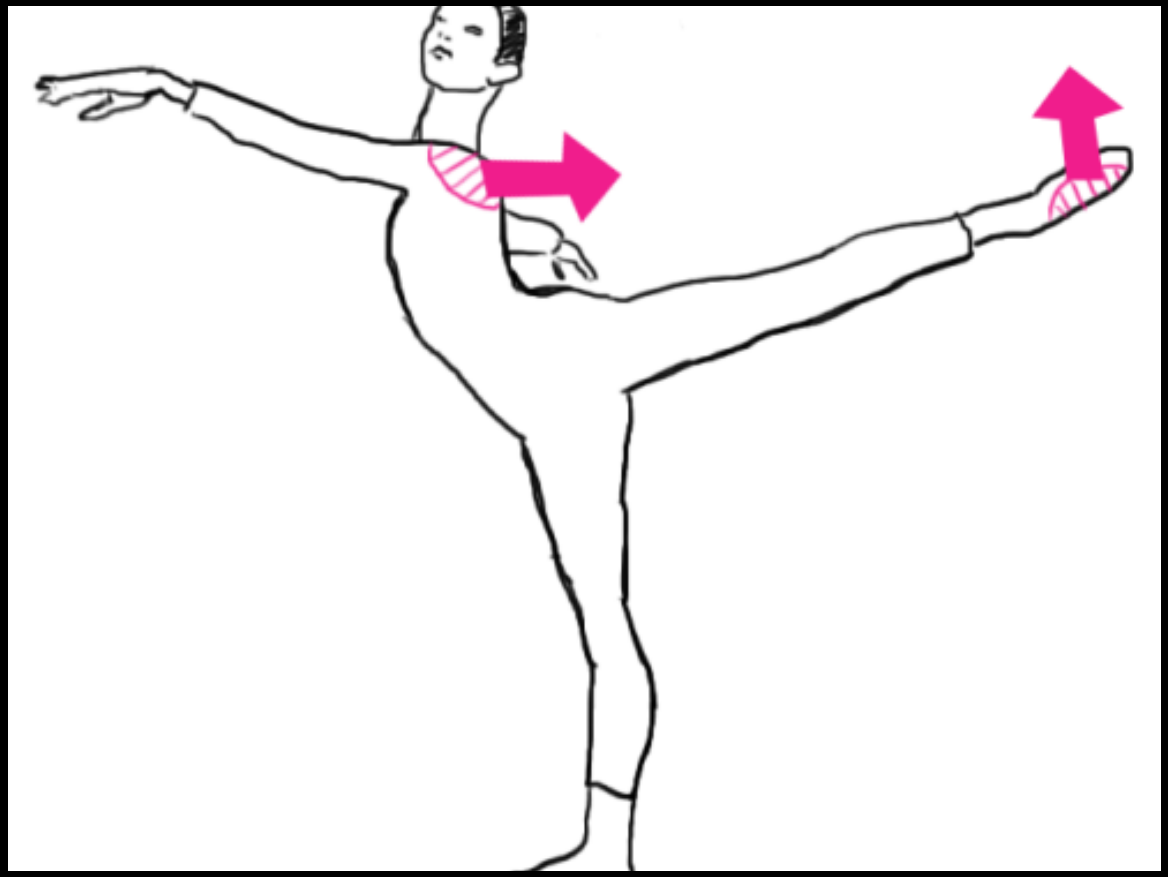
Skill Assessment: Dance

- Arabesque positions as a child
- Standing position- hyperlordosis
- Port de Bras- correct position, simple arm motion
- Arabesque
- Motion with arabesque = kicking



Hinging in weight bearing gravity assisted “Arching”

(Courtesy of danceproject.ca)



Forces not in the same direction parallel

Moderately perpendicular in nature, need to focus on gluteal activation and segmental motion of hamstring, multifidi, erector spinae, etc.

Summary

- Take the pressure off of the spine- release the muscles from tension, and increase surrounding flexibility
- Watch skills, and watch for compensation patterns
- Treat with a combination of rest, functional strengthening, and joint mobilization/reeducation early!

Summary

- Performing arts is a delicate balance between sport and art, between technique of repetition, and variance of motion
  - It is a mix between (1) flexibility, (2) joint range of motion, (3) strength, (4) stability, (5) endurance of heart, (6) endurance of orthopedic musculature, (7) neuro systems (feed forward mechanism, reflexes, MT junction feedback) and (8) genetic skeletal alignment.

How do we FIX it?

- Make sure that time is spent stretching the hips and shoulders properly
- Make sure that this is done EARLY
- Ensure that your athletes understand the concept (even just standing them against a wall helps!)
- Test and measure the flexibility and chart it – in public, so they can keep track
  - Measure with a goniometer, or have your PT do it for you to ensure accuracy and repeatability

Skill Discussion

- If extension is limited…
  - Gymnastics:
    - Back Handsriping, Yerchenko Vaulting (pre-flight)
      - Back Handspring especially if in learning stages taking from floor to beam, repetition watch and concern
    - Front handspring vaulting (block)
    - Front tumbling, bounding especially
    - Bar releases: Tkatchev, Jaeger (M and W), Kovacs (Sp?) (M), Pak Salto (W)
  - Dance/Gymnastics Combo
    - Leaps, ring, even switch dep on sensitivity
    - Arabesque positions
  - Skating
    - Bielman (sp?)
    - Spin in leg position?
    - Arched flying camel
  - Cheer
    - Positions for flyer
    - Back tumbling
    - Base- vertical alignment without extension “moment”

LAB- Let’s MOVE!

Move the Hips

Move the Shoulders

Move the Spine

Hip Flexibility – Rotation of the pelvis

- Anterior Rotation
  - Place hands on hips, fingers in front (ASIS) thumbs in back around hips
  - Dump the bucket forward
  - Fingers drop below thumbs
  - Arch in back (lordosis)
- Posterior Rotation
  - Dump bucket backwards
  - Do not “Frump” with upper body, wrong part
  - Fingers rise above thumbs, or thumbs relatively drop
  - Pubic bone comes closer to breast bone
  - Rounded back (kyphosis)

Spine

- Palpation
  - Sacral landmarks (base)
  - Spinous process
  - Facet (location)
  - Feel “bounce” of a PA mob, difference T to L spine
  - Kinesiology of three planes of motion- vary per level
- Motion
  - Stand and “arch”
    - Combo rib tilt, anterior pelvic, nutation, thoracic reversal kyphosis, lumbar lordosis
    - Activation of ES and hip flexors
  - Reverse
    - Activation of abs and hamstrings

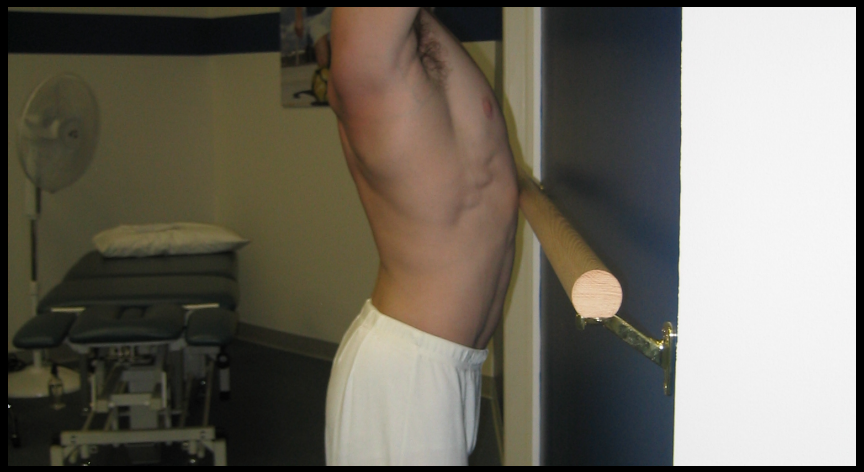
1) Shoulder Motion

- The shoulders should be able to move above the head, with the spine at least in neutral, to 180 degrees
- Lets try –
  - 1) floor
  - 2) wall
  - 3) handstand example
  - SLIDES…

Testing!
Wall

- Stand against the wall, lift arms overhead
- Try to keep all of the following:
  - Feet 6 inches from wall
  - Butt on wall
  - Low back pressed against hand, or towel, or better yet –wall!
  - Shoulder blades start on wall
  - Head on wall in neutral
- Lift arms overhead, keeping all on the wall
- How far are you away?

Wall testing



- Arms overhead, Humerus bone straight in line with femurs (relative vertical alignment from CC axis point)
- Look at arch in low back
- THIS is what the handstand looks like – familiar?
- 2nd pic- straight spine
- Flexed shoulders! But, better…

Floor

- Lay on floor (gravity assist)
- Keep low back as flat as possible, or smash something – neutralizes spine
- Lift arms overhead, STOP when back comes off of floor
- How far did you go?

Practical Testing

- First pic- flat back, about 150 degrees
- 2nd pic- arched back

- FAKE 180 degrees, look at the ribs tilt backwards- the spine is already in lordosis
  - Still about 150!

Proper and Improper Evaluation and Strength Technique

2) Pelvic Motion
Split Position- RIGHT

- Front Leg
  - Flex: Hamstring
  - Ilium: Posterior
  - Facets: Open, relativel
- Back Leg
  - Flex: Hip Flexors
  - Ilium: Anterior
  - Facets: Compressed

Body

Rotate relatively:

- Lower ½ torso opposite (Left)
- Upper ½ torso same (Right)

Palpation!

- Standing:
  - Spinous process
    - Lumbar- ex: rotation right
  - Extension of the hip
    - With rotation allowed
    - Without rotation allowed
- Standing:
  - Extension- gross assessment skin fold
  - Side bend
    - Comparison L to R

Measure the rib angle to the humerus bone – NOT the spine- visually confusion/convincing

(Magee 1997, re: measures)

Evaluation - Hips

- Need to make sure that the spine is in neutral, for reliability of measurement
- Need to make sure the athletes understand this position
- Need to make sure the back leg is never in external rotation, or compensation patter, will skew results

Splitz example

3) Evaluation - Spine

- Measure the distance between heel of hand and heel of foot
- Measure height from belly (highest point) to floor
- Just for knowledge
- Pictures are best (side view)
  - Measure the shoulder angle and hip angle there, too

Source List

- Smith LK, Weiss EL, Don Lehmkuhl L (eds, 1996). Brunnstrom's Clinical Kinesiology, 5th ed. Philadelphia, F.A. Davis. Chapter 5, pp. 223-225
- Neumann DA (2002). Shoulder complex. In Neumann DA: Kinesiology of the Musculoskeletal System: Foundations for Physical Rehabiliation. Philadelphia: Mosby. Chapter 5, pp. 91-132.
- Atler MJ (1996). Science of Flexibility, 2nd ed. Champaign: Human Kinetics. Chapter 5, pp. 59-63.
- Hamill J and Knutzen K.(1995). Biomechanical Biases of Huuman Movement. Philadelphia: Lippincott, Williams and Williams.
- Sermeev BV. Development of Mobility in the Hip Joint in Sportsman. *Yessis Review*, 2 (1), pp. 16-17.
- Fitt SS. Dance Kinesiology, 2nd ed. Utah: Schirmer Thomson Learning.
- Jemni M. The Science of Gymnastics. New York: Routledge.
- Clippinger K. Dance Anatomy and Kinesiology. Champaign: Human Kinetics. 2007.
- Magee D J. Orthopedic Physical Assessment, 3rd ed. (1997). Philadelphia: W B Saunders Company.
- Sands WA, Caine DJ, and Borms J (2003). Scientific Aspects of Women's Gymnastics. New York: Karger.