Competitive Swimming Prevalence

- US Swimming Population: 100-120 million
- 250,000+ registered with USA swimming.
- 38,000+ US Masters Swimming members
- 5 million+ participate in HS and summer swimming

Kammer et al, 1999
Training Load

- Freestyle is most common training stroke
- Pool Work
  - Competitive swimmers train 10,000-20,000 yds/day.
  - 40,000 shoulder rotations/per arm/per week
  - Stroke technique is critical
- Dry land Work
  - Strength training
  - Dry-land conditioning
  - Cross-training (circuits, running, cycling)
Swimming Injury Epidemiology

- Shoulder
- Knee- breaststrokers
- Back-DDD, Spondylolysis, Spondylolisthesis
Swimming Injury Epidemiology

- Prevalence of shoulder pain in elite swimmers
  - 3% in 1974 – “Swimmer’s Shoulder”
  - 42% in 1980
  - 40-69% in 1994
  - 47% lifetime incidence of shoulder injuries in collegiate swimmers and 48% in masters swimmers

Sein et al, BJSM, 2010
Shoulder Pain Epidemiology

- Anterior-Superior: 44%
- Diffuse pain: 26%
- Anterior-Inferior: 14%
- Posterior-Superior: 10%
- Posterior-Inferior: 4%
Biomechanical Demands of Swimming

- Outside humans' natural environment
- Specific actions needed for breathing
- No firm surface against which to generate forces.
- Propulsion by upper limbs
- Negative effects of water drag
Biomechanics of Freestyle

- 4 Phases of Freestyle
  - Entry/Catch
  - Early Pull/Pull
  - Push
  - Exit/Recovery
Entry/Catch

- Hand entry in line with shoulder and at wrist level
- Slight IR pitch to hand ~ 40°, open hand
- Elbow straightens to get long glide
- Elbow bends slightly and remains on the surface for catch and preps for pull
- Opposite arm pull on entry
- Opposite leg kick
Early Pull/Pull

- High shoulder and high elbow position
- Elbow bent for pulling and IR
- Forearm vertical at mid pull
- Body rotation continuous
- *Pulling* body past a stationary arm, NOT *pushing* water back.
Push

- From vertical forearm position to hip
- Power thru core and axial rotation
- Need > 40° rotation to clear the hip
- Arm continues to accelerate
- Elbow exits first
Exit/Recovery

- Elbow exits first, then 5th digit
- Trunk rotation necessary to avoid horizontally abduction beyond bodyline
- Elbow leads recovery, then hand leads elbow
Power and propulsion from hip and knee extension
Efficient kick takes stress off shoulder
Ankle PF
Stabilize core
2 beat/4 beat/6 beat
Head Position/Breathing

- Slight cervical extension vs. neutral
- Alignment of head/trunk/hips
- Breathe at beginning of recovery
- Bilateral breathing
Freestyle
Common Freestyle Mechanical Changes Caused by Fatigue, Soreness and Pain
Freestyle Stroke Flaw

Thumb First Entry

- Over developed IR
- Weak/fatigued ER
- Coached to improve catch/early pull
- Poor motor program
Freestyle Stroke Flaw

Crossover at Entry

- Poor scapular control
- Poor trunk rotation
- GH hypermobility
- Poor motor control/proprioception
Freestyle Stroke Flaw

- Swimming “flat”
  - Poor motor program
  - Poor core strength
  - Poor kick
  - Anterior pelvic tilt
Freestyle Stroke Flaw

- Excessive IR in Recovery
  - Weak ER
  - RTC fatigue
  - Posture
  - Coached for high elbow or “finger tip” drill
Freestyle Stroke Flaw

- Poor Timing
  - Poor core strength
  - Poor balance in water
  - Poor motor program
Good Timing of Freestyle stroke
The Question...

Why has this swimmer have this injury at this time?
Etiology of Shoulder Pain in Swimmers

- Intrinsic Factors
  - Scapular dyskinesis
  - Muscular imbalance
  - Joint mobility (hyper/hypo)
  - Posture/increased thoracic kyphosis
  - Core stability
  - Inflexibility (pecs, lats, hip flexors)
Etiology of Shoulder Pain in Swimmers

- Extrinsic Factors
  - Training load- absolute and sudden increase
  - Stroke flaws/error
  - Stroke specialty
  - Sprinter/Mid/Distance
  - Training environment (pool/dryland/Xtrain)
Research - Impingement

- 4 areas of impingement recognized in the literature
  - Subacromial
  - Posterosuperior Internal
  - Anterosuperior Internal
  - Coracoid

- **Subacromial impingement**: compression and abrasion of bursal side and subacromial structures between the humeral head and coracoacromial arch
Research - Impingement

- Mechanical impingement occurs 25% of freestyle stroke cycle in swimmers

<table>
<thead>
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<th>Initial Catch</th>
<th>Pull</th>
<th>Recovery</th>
<th>Stroke Cycle</th>
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<tr>
<td>Maximum</td>
<td>25.0</td>
<td>20.0</td>
<td>21.7</td>
<td>56.0</td>
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</tbody>
</table>

(Yanai & Hay, 2000)
Research - Impingement

- 40% of impingement occurs at entry
- 40% during recovery
- 20% during the pull

(Pink & Timone, 2000)
Research - Muscle activity

- Normal muscle activity during freestyle
  - 15-20% of a muscles maximal voluntary contraction is the highest level at which sustained activity can occur without fatigue (Monod et al, 1985)
  - Pink et al, AJSM, 1991
    - EMG study on 12 muscles in 20 swimmers w/o shoulder pain
    - **Subscapularis** and **Serratus Anterior** are constantly fire at more than 20% of the maximum
Abnormal muscle activity during freestyle

- Scovazzo et al, AJSM, 1991
- EMG study of 12 shoulder muscles in 14 swimmers with shoulder pain
- During pulling, significantly less activity in SA and more in rhomboids.

SA Fatigue → Scapular Dyskinesis → Narrowing of Subacromial space → Impingement
Research – Muscle Activity

Diagram showing anatomical structures of the shoulder, including:
- subacromial bursa
- acromion
- supraspinatus muscle
- scapula
- capsula
- humerus
Research – Joint Laxity

- Many authors have examined GH laxity in swimmers and concluded that swimmers have great GH laxity and general joint laxity.

- Jobe described the “instability complex.”
Research – Joint Laxity

- Borsa et al, AJSM 2005
  - 42 NCAA Div 1 swimmers
  - 44 age matched controls
  - US imaging of GH laxity
  - No difference in GH laxity between swimmers and age matched controls
  - No difference in GH laxity between painful and non-painful swimmers
Research – Joint Laxity

- Sein et al, BJSM 2010
  - 80 elite swimmers (13-25 yo)
  - Training questionnaire, PE, laxometer, MRI
  - 91% complained of shoulder pain
  - 84% impingement sign
  - 69% SSPS tendinopathy

Inferior glide
Sein et al, BJSM 2010

- All swimmers with SSPS thickening had a + impingement sign and SSPS tendinopathy
- ++ correlation between SSPS tendinopathy and # of hours swum each week (> 15 hours/week)
- SSPS tendinopathy in swimmers is induced by large training loads
- Shoulder laxity has only a minimal association with shoulder impingement in elite swimmers
Summary

- Muscular fatigue and training load appear to have a greater influence on shoulder pain than joint laxity based on new research.
- Key is to get swimmers in early, eval/treat impairments, swim stroke analysis, modify training as needed.
Looking Forward…

- More research is needed on age group and high school swimmers
- Is there a place for “yardage count” for younger athletes