Overuse injury of the Shoulder.

The rotator cuff is composed of four muscles that help with shoulder rotation and stabilization. Overuse injuries to the rotator cuff are very common. They occur in patients who do repetitive overhead or throwing activities. Throwing is a classic example, as demonstrated in both baseball pitchers and water polo players. Patients will develop tendinopathy or inflammation of the bursa above the rotator cuff tendons (bursitis).

Shoulder pain (bursitis / rotator cuff tendinopathy) is one of the more common overuse injuries of the upper extremity. It can result from both trauma and overuse, and occurs in both sedentary and sporting populations. In the latter, it often occurs where frequent overhead motion is involved (i.e., baseball, swimming, volleyball). It is even common among weightlifters where too much weight is used and technique is suspect. Pain is usually felt at the tip of the shoulder and is referred down into the front, side or back of the deltoid. Pain is felt when sleeping on the involved side, when reaching out with the arm, and when the affected arm is lifted overhead. People erroneously mistake this as a pain that can be "worked out" with repeated use. Unfortunately, this results in increase in symptoms and duration.

Athletes affected with this problem will complain of pain with overhead activities. Swimmers or throwers who are overtraining may develop this problem.

Intrinsic Factors:

* Muscle imbalance
  The development of muscular imbalance through many years of tedious training seems to be of particular importance. McMaster has shown that swimmers are significantly stronger in internal rotation of the humerus than non-swimmers measured by a Cybex successful dynamometer, and at the same time not significantly stronger in external rotation. This is supported by dynamic electromyography of swimmers without shoulder pain. The muscular imbalance is not only confined to the glenohumeral joint, but also to the scapular stabilizers. An imbalance or weakening of the scapular muscles makes anterior translation of the humeral head more possible thus provoking impingement.

* Inflexibility
* Muscle weakness
  Chronic overuse from throwing creates an imbalance between the internal and external rotator muscles of the shoulder. The external rotators, continually required to eccentrically decelerate the arm, are subject to overuse fatigue, which produces strength and flexibility deficits. These maladaptive changes are believed to play a role in rotator cuff tendinosis.

* Malalignment
* Instability
The glenohumeral joint is a unique anatomic arrangement that consists of a minimal constrained articulation permitting an extreme range of motion while balancing mobility and stability. Static factors contributing to the maintenance of stability are: articular components, glenoid labrum, capsule and ligaments and negative intra-articular pressure. The glenoid socket covers only one third to one fourth of the surface area of the humeral head, like "a golf-ball in a tee". The glenoid labrum compensates for this osseous instability by increasing the humeral head contact areas to 75% vertically and 56% transversely. The glenoid labrum is most firmly attached below the equator. Detachments or attenuation here leads to instability. At 90° of abduction, the inferior glenohumeral ligament provides the major restraint against anterior dislocation during external rotation. The anterior-inferior part of the capsule is subjected to considerable strain, because it is stretched tightly across the humerus when the arm is elevated. This might be a critical point for swimmers, as it is when initiating the pull-through phase that the most inertia must be overcome. The use of hand paddles further increases this strain. Numerous repetitions of this load might result in attenuation of the capsulaligamentous complex, predisposing to anterior glenohumeral instability.

Maintenance of a normal glenohumeral relationship depends on the reinforcement provided by the dynamic function of the rotator cuff. The subscapular muscle lies anterior-inferior and is a strong internal rotator and the main anterior dynamic stabilizer of the glenohumeral joint when the shoulder is abducted 0-90°. Supraspinatus, which lies superior, is initiating shoulder abduction together with the anterior fibers of the deltoid muscle and furthermore adducts the humeral head in abducted position. Infraspinatus acts as an external rotator together with the teres minor. The biceps tendon is a further dynamic stabilizer of the glenohumeral joint, in particular for throwing athletes, where it plays a major role in the late cocking phase. Furthermore a coordinated scapulothoracic-glenohumeral movement is a critical component for normal shoulder function. Optimal positioning of the scapula relative to the glenohumeral joint requires normal function of the rhomboids and upper trapezius muscle.

If athletes' shoulder pain is associated with non-traumatic glenohumeral instability, the condition has been called secondary impingement. Glenohumeral instability can be either unidirectional or multidirectional. Isolated anterior glenohumeral instability (apprehension shoulder) may be due to multiple micro-injuries to the static and dynamic anterior stabilizers of the glenohumeral joint. The attenuation of the anterior part of the capsule in particular the inferior glenohumeral ligament and the subscapular muscle results in instability which puts increasing demand on the rotator cuff, leading to an increase in anterior translation and eventually a glenoid labral lesion. Athletes with general joint hypermobility are particularly prone to developing symptoms of glenohumeral instability during overhead activity, due to the capsular laxity already present. Multidirectional or involuntary glenohumeral instability has been described in swimmers without concomitant general hypermobility. A concomitant dysfunction of the scapulothoracic joint
aggravates the humero-scapular synchrony essential for pain-free, movement of the shoulder joint.

Patho-mechanically, three situations during the crawl stroke are potentially harmful to the anterior-inferior capsulolabral complex or the rotator cuff.
1. During early pull-through the shoulder is maximally abducted/flexed and externally rotated. In this position, which resembles an apprehension test at approximately 135°, the most inertia is overcome putting the load at its highest during the stroke cycle. Numerous repetitions of this load might result in attenuation of the capsulaligamentous complex, in particular the inferior glenohumeral ligament. Dynamic EMG studies show that during this phase there is a significant decrease in activity of the scapular rotators and a significant increase in subscapularis activity in swimmers with painful shoulders compared with asymptomatic swimmers.
2. At the end of pull-through a forceful internal rotation and adduction may cause repetitive wringing of the rotator cuff with a risk of tendinopathy on ischemic basis.
3. The last possible injury-provoking situation occurs during recovery where the arm repetitively is abducted and externally rotated causing impingement of the rotator cuff on the coracoacromial arch.

Shoulder instability and rotator cuff tendinopathy is described in question 3.

* Prior Injuries
  Trauma / previous injuries to the shoulder (and resulting rotator cuff weakness) predisposes the problem

* Sex
* Age/ Psychological factors (maturity level, self-esteem)
  There is evidence that children are more prone to overuse injuries and impact injuries than adults because of the softness of their growing bones. Every long bone has a growth plate. At each end is growth cartilage, which is the weakest part. Also, as a young person's bones grow longer there may be disproportionate growth in the muscle and tendons, which can lead to tight joints, making the young player even more vulnerable to overuse injuries.

Dominguez examined 144 high school swimmers, of whom 84 were from 13 to 18 years old. In this age group he found that 55 (65%) had shoulder pain. Nine (10%) swimmers had pain during and after activity affecting performance, which corresponds to class 3 according to Blazina. There was a positive correlation between age, swimming experience and shoulder pain. Girls were slightly more commonly injured (28/38 = 74%) than boys (27/46 = 59%), but this difference was not significant.
Extrinsic Factors:

* Training errors
  - Excess volume
  - Excess Frequency
  - Excess Intensity
  - Faulty Technique

Overuse injuries are not just a matter of playing too much, but playing too long or too rigorously as well. A general guide in training is to follow the 10 percent rule. Essentially, the rule of thumb is to increase intensity, frequency and duration — or any combination of play — 10 percent at a time. Doing too much too soon can get a young athlete in trouble.

A high school tennis player who goes away to tennis camp to work on his serve suddenly spends four hours a day serving the tennis ball. That makes him prone to developing rotator cuff tendinopathy, the inflammation of tendons at the top and back of the shoulder.

In competitive swimming an increasing prevalence of shoulder pain is reported with relation to increasing daily training distance and training experience. Ciullo reported the highest prevalence in 1981. He found that 82% of the male swimmers and 47% of the female swimmers had shoulder pain.

Kennedy's survey of 2496 competitive Canadian swimmers revealed a prevalence of shoulder pain of 3%. The population was broad, from club swimmers to Olympic swimmers, and the investigation was based on a questionnaire. Average daily training distance was 4500 m. In a comparable population of 260 competitive Danish swimmers (median age 16) where 20% were medal winners at the national senior championships, 15% complained of interfering shoulder pain during a 1-year season. A significantly larger proportion of medallists were injured.

McMaster & Troup's cross-sectional survey included 1262 swimmers: 993 national age group (NAG), 198 senior development (SED) and 71 national team swimmers (NT). The prevalence of shoulder pain was 10% (NAG), 23% (SED) and 26% (NT).

* Equipment

Hand paddles used in swimming are training aids made of plastic that due to a surface area larger than that of the hand, increase resistance during the pull through. This is used to improve stroke technique and strength, thus contributing to muscular imbalance. From the cross-sectional surveys it is difficult to interpret the precise role of hand paddles as, at the time of
investigation, more pain-free swimmers are using paddles than pain-troubled swimmers, the latter avoiding paddles because they tend to aggravate pain. Furthermore, it is difficult to evaluate properly in prospective trials, since the effect might first show after 5-8 years of training.

* Sports-acquired deficiencies

Richardson et al. found that 58 of 137 (42%) competitive swimmers had shoulder pain. He pointed to the extensive repetitive overhead movement implied in the three strokes crawl, butterfly and backstroke. A male swimmer with a daily training distance of 9100m repeats a total of 400,000 stroke cycles per arm per year. Female swimmers, on average, have shorter arm strokes, and with the same training amount this results in approximately 660,000 stroke cycles per arm per year.

The swimming strokes crawl and butterfly are reported to be most commonly associated with shoulder pain. The correlation of an injury risk to a particular stroke is, however, not quite clear, since it is known that, independent of a swimmer's favorite stroke, he or she practices more than 50% in the freestyle stroke.

Using dynamic electromyography of 12 shoulders in competitive swimmers without shoulder pain, Pink et al. found that the three heads of the deltoid function in synchrony with the supraspinatus, to place the hand at arm entry and exit. Propulsion is created by pectoralis major, and the latissimus dorsi. Subscapularis and serratus anterior are at constant activity. The teres minor is functioning with the pectoralis major, and the infraspinatus is only active to externally rotate the arm at mid-recovery.

The stroke techniques for freestyle, backstroke and butterfly are very similar. The swimming stroke can be divided into two main phases - pull-through and recovery. Pull-through, which is responsible for propulsion, is divided into: hand entry, mid pull-through and end of pull-through. The recovery phase is divided into elbow lift, mid recovery and hand entry. In the freestyle stroke, hand entry starts with the arm in a maximally abducted-flexed and slightly externally rotated position, the elbow being slightly flexed. From this position the arm is depressed (anti-flexed and adducted) and the shoulder further internally rotated to neutral and 90° of abduction at mid pull-through, the elbow being at 90° of flexion. At the end of pull-through the shoulder is fully adducted and internally rotated, while the elbow gradually extends to neutral. The recovery phase begins at elbow lift. The hand exits while the elbow is flexed, and the shoulder begins external rotation and abduction. At mid-recovery, the shoulder is at 90° of abduction and neutral rotation. The shoulder is then gradually externally rotated and abducted. During these two phases, the body rolls from neutral to 40-60° and back. In the butterfly stroke, the body roll is
eliminated since both arms are working synchronously. This results in an increased need of shoulder abduction in order to advance arms above the water during recovery. In the back stroke, propulsion is created by nearly the same movements as in the freestyle; however, a slight difference is seen as more stress is applied to the anterior capsule during the mid pull-through, and during the flip-over type turn where one arm in an extreme external rotation and abduction assists in the push-off from the wall. The breaststroke technique has changed over the last years demanding more shoulder abduction, so that shoulder problems are to be expected among these swimmers also.

Prevention

Prevention is the cure. Increased effort in the education of coaches on primary and early injury prevention, and close teamwork between the coach, the swimmer and the club therapist (team doctor and physiotherapist) are important measures, which for other sports have been shown to reduce injury incidence. Ideally a sports physician, orthopedic surgeon or sports physiotherapist must closely survey the elite swimmer. Alternatively a coach with a broad education in injury prevention who has sound contact with either of these health care providers may suffice.

Training methods should be revised universally focusing on improved muscular balance around the shoulder joint through regular strength training. This, however, raises the controversial issue of whether strength training is beneficial or potentially harmful to pubescent children. Earlier recommendations stated that strength training should not be initiated before growth plate closure. The opposition to strength training was mainly

(i) That pre-pubescent were incapable of making significant strength gain because of inadequate levels of circulating androgens.

(ii) That strength gains do not improve motor performance or reduce the risk of injury in children's sports and

(iii) That resistance weight training is dangerous, implying an unacceptable risk of injury.

Recent studies have not confirmed this.

In competitive swimming, children are recruited at a young age and daily training from age 11-12 is not unusual. Children at this age seem to adapt easily to this demanding daily practice, tolerating even high and increasing loads without problems. In order to prevent muscular imbalance, a balanced strength-training program should be initiated even before growth plate closure. The type and amount of resistance strength training should be related to bony age.

Apart from avoiding muscular imbalance, there are a number of easily applicable measures to prevent or reduce the risk of injury such as: analysis and correction of technique, cautiousness when increasing the training load or amount, regular stretching and thorough warm-up.
Treatment

The treatment preferably should be initiated at an early stage of the condition. This is not always possible, and unfortunately most cases of swimmer's shoulder are detected at a late stage. Treatment can be causal, symptomatic and surgical.

1. Pathoanatomic Diagnosis

2. Causal treatment (Promote Healing and control Abuse)

   a. Stroke analysis and correction.
      Analysis and correction of stroke technique can relieve symptoms in many cases, in particular if initiated at an early stage. Analysis of stroke technique can be greatly improved by using underwater "windows" or video tape recording. The aim of stroke analysis and correction is to limit the extreme positions of abduction and internal rotation in which the supraspinatus tendon is most likely to impinge against the coracoacromial arch. This can be done by having the swimmer make an earlier arm recovery, a greater body roll and less internal rotation of the arm at hand entry. Butterfly should be avoided during periods of shoulder pain, since it requires a greater degree of abduction and thus tend to aggravate rotator cuff tendinopathy.

   b. Decrease activity and load.
      The coach should design an individual program with reduction in the daily training amount and decrease load to a pain-free level. At Neer & Welsh's phases I and II there is seldom need for total rest, while swimmers in phase III or IV might need cessation of shoulder activity. The use of hand paddles should be avoided during periods of shoulder pain, as it puts extra load on the shoulder joint and aggravates muscular imbalance. Swimmers should vary between different strokes or increase kick training in order to reduce load. The use of a kickboard should, however, be limited since it brings both arms into constant abduction with a risk of aggravation of the rotator cuff impingement.

   c. Strength training and stretching.
      Ciullo reported a decrease in the prevalence of shoulder problems from 80% to 14% after an intensive preventive program of stretching and strengthening of the internal and external rotators of the shoulder. It has been estimated that approximately 95% will be able to return to their prior level of competition after intensive functional rehabilitation, while the remaining 5% will need surgery after a failed attempt of conservative treatment. Rehabilitation, preferably under the supervision of a physiotherapist, must be functional and individually designed, in order to restore muscular balance for the glenohumeral and the scapulothoracic
joints and to regain normal range of motion. Muscles that stabilize and elevate the scapula or externally rotate the shoulder are relatively weak in competitive swimmers. This relative muscle strength imbalance makes it difficult for the swimmer to achieve full elevation of the scapula or to rotate the humerus externally, making impingement of the greater tuberosity beneath the acromion more likely. Muscle balance can be improved by dynamic exercises or by static rubber-band exercises with emphasis on external rotation of the shoulder at variable degrees of abduction.

On the basis of electromyographic studies in healthy persons, exercises specific to rehabilitation of the shoulder girdle have been suggested, but no controlled studies of the effect on athletes with shoulder pain have been performed so far. Medicine ball throwing and other forms of uni-articular muscle training should be abandoned since it tends to aggravate muscular imbalance and thus instability. The isokinetic swim bench and other commercially available pulling devices are likewise designed to improve shoulder internal rotation strength, and thus not to be recommended during periods of shoulder pain. Stretching exercises are encouraged after each workout. Shoulder stretching exercises should be sport specific. In swimmers this includes muscles involved in forward propulsion, primarily the shoulder internal rotators, but caution should be taken not to overstretches the anterior capsulaligamentous complex. Static stretching using the contract-relax-stretch technique is recommended while ballistic stretching must be abandoned since it activates the muscle spindle. Partner-assisted stretching should be performed only under careful supervision.

3. Symptomatic treatment/ Control ‘inflammation’

During rehabilitation it is important that the swimmer be pain-free. In cases with resistant shoulder pain, a nonsteroidal anti-inflammatory drug might be prescribed. There may be a shift away from this as more evidence points towards tendinosis rather than tendinitis. When pain is constant, preventing the swimmer from undergoing rehabilitation, an intra-bursal injection of corticosteroid is indicated. With a correct injection technique and sterile precautions complications are infrequent. A period of rest or reduced load of approximately 2 weeks is needed, in which period the collagen has been shown to disorganize. Application of ice bags on the painful shoulder for a period of 5 to 10 min after each training session is known to relieve pain. Analogous to tennis players' painful elbow, an upper arm counterforce brace is available.

4. Increase Fitness

5. Surgical treatment
If conservative treatment fails, arthroscopy should be performed after 3-6 months depending on the pathophysiology. The surgical treatment must be specific and preceded by thorough evaluation under anesthesia.

The reports in the literature on surgical treatment of coracoacromial impingement are mainly based on inhomogeneous populations, either with regard to age, injury mechanism or actual level of activity. As these seem to be the main factors influencing the final outcome, it is difficult to draw safe conclusions and relate the experience to the elite overhead athlete with chronic shoulder pain.

Neer introduced the open anterior acromioplasty for treatment of mechanical impingement, with success rates of 80-90%. The rate of success was largest among non-athletic patients over 40 years old. The results of subacromial decompression in overhead athletes are less promising. Pain is reduced in most cases and functional shoulder scores improve, but very few overhead athletes are able to resume sport at the same level.

Tibone et al. found that only 4 of 18 overhead athletes returned to their former pre-injury status after open anterior acromioplasty. Bums & Turba also found unsatisfactory results with this method; only 44% of the athletic population was able to return to their previous competitive level. Although none of the patients was described as unstable on preoperative examination under anesthesia, the majority had arthroscopic findings consistent with instability, such as anterior glenoid labrum tear, undersurface rotator cuff tear, humeral head chondromalacia and posterior labrum tear. Fly et al. found that, compared to open acromioplasty, arthroscopic subacromial decompression (re-lease of coracoacromial ligament, resection of the anterior acromion and debridement of the hypertrophied bursa) gave excellent pain relief, but still no swimmers were able to return to their same competitive status. Jobe & Glousman found that open acromioplasty and rotator cuff repair gave poor results in 40% of professional pitchers and throwers. After arthroscopic subacromial decompression 46% of overhead athletes returned to the same level; however, none of the pitchers or swimmers did. They stated that the degree of rotator cuff pathology has no influence on the ultimate results, but that rather the type and level of activity have the greatest influence on the final outcome. Penny & Welsh performed open decompression by simple excision of the coracoacromial ligament in 20 overhead athletes with supraspinatus or bicipital tendon impingement. Seventeen returned to sports activity without symptoms. Level of activity was not given. Albertsson et al. reported excellent or good results in 84% after resection of the coracoacromial ligament; however, of 23 elite or league competitive athletes only 12 were able to return to the previous level of activity. No data on possible concomitant instability were given. Altchek found that 76% returned to sports after acromioplasty with resection of the coracoacromial ligament, but most of the patients were not highly competitive and still the prognosis was worse for overhead athletes, where a high incidence of tears of the inferior part of the labrum was found. Ellmann performed arthroscopic subacromial decompression in 24 athletes, of whom 87.5% returned to
their sports activities. Twelve (50%), however, had a work-related injury and no level of activity was reported.

The reasons for some of the poorer results in the overhead athletic population might be explained by associated lesions characteristic of glenohumeral instability, which by the above surgical methods might actually be aggravated.

If glenohumeral instability is found, the direction and the severity of the instability must be evaluated. The direction of instability in overhead athletes is most often anterior-inferior, and therefore an inferior capsular shift procedure is recommended.

Indications for instability surgery are failure of a rehabilitation program in athletes who desire to return to overhead athletics. Also Bankart lesions or complete rotator cuff ruptures should be considered for surgical reconstruction. Labrum-capsular lesions should be repaired, but the results of arthroscopic stabilization in non-traumatic subluxation are not encouraging. Lately Jobe & Glousman reported their preliminary results of open anterior capsulolabral reconstruction without detaching, shortening or transferring any muscle to be promising. Bigliani et al. performed inferior capsular shift in 58 overhead athletes, including 12 swimmers. After an average follow-up of 4 years 71% returned to their sport at the same level, the rate for throwing athletes being slightly lower (50%). In cases of multidirectional instability Neer & Foster reported a low recurrence rate after an inferior capsular shift.

---