

SHOULDER PAIN IN ELITE SWIMMERS

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Abstract: Much research has investigated shoulder pain which inhibits the performance of elite swimmers. An ever increasing understanding of the epidemiology and aetiology of what has been termed 'swimmer's shoulder' has enabled better treatment, rehabilitation and prevention programs to be implemented. This paper reviews the current research relevant to 'swimmer's shoulder' and the methods of treatment being employed to treat the problem.

Keywords: Shoulder, pain, elite swimmer, chiropractic.

INTRODUCTION

Due to the repetitive nature of overhead sports like swimming, throwing, and tennis, athletes are prone to develop overuse injuries. These sports subject the shoulder complex to stress, fatigue, microtrauma, laxity of static stabilisers, and muscle imbalances that alter the normal biomechanics of the joint and predispose it to injury. The shoulder complex operates with a finely tuned balance between stability and mobility. Dynamic stability is provided by the rotator cuff and long head of biceps and operates in the midrange of motion. Static stability from capsular and ligamentous restraints, functions at the end range of motion. The scapular stabilisers including serratus anterior, trapezius and rhomboids are essential for the positioning of the glenoid in relation to the humeral head. With the high demands and expectations placed on elite swimmers, extensive research has been done on the aetiology, treatment, rehabilitation and prevention of shoulder pain so that elite swimmers can keep performing at the best. This paper will present a review on that research. The database Medline was used to search for information regarding this topic.

EPIDEMIOLOGY

The prevalence of shoulder pain in elite swimmers has been studied by many researchers. McMaster and Troup (1) found 38-75% of the 1262 swimmers they surveyed had some history of shoulder pain that interfered with training, while 9-35% were currently experiencing pain. A questionnaire by Richardson et al (2) on a group of 137

swimmers showed that 52% of elite swimmers surveyed had a history of shoulder pain compared with only 27% of non-elite swimmers. It appears that the percentage of swimmers with shoulder pain increases with increased ability. Both studies explained that this resulted from the fact that elite swimmers have spent more time in the sport, average more kilometres per week and have undergone more training than non-elite swimmers, and so have placed greater stress on their shoulders. Shoulder pain interferes with the elite swimmers training conditioning and competition performance. If severe enough it may lead to an exit from the sport of a promising athlete. Therefore research into the aetiology and prevention of shoulder pain is of primary importance to both the swimmer and the practitioner.

AETIOLOGY OF SHOULDER PAIN

Kennedy et al, described "swimmers shoulder" in 1978 (3), by merging two areas of research on the shoulder. Kennedy postulated that the avascular region of the supraspinatus and long head of biceps tendon identified by Rathbun and Macnab (4), made these tendons more susceptible to tendinitis brought about from their mechanical impingement under the coracoacromial arch when the arm is in a forwardly flexed and abducted position. Such mechanical impingement of the tendons under the coracoacromial arch was first described by Neer in 1972 (5) and forms the basis of the proposed mechanism of incidence of swimmer's shoulder.

Further understanding of impingement was gained with Neer in 1983 (6). Neer described impingement lesions as occurring in three stages (Table 1).

Several authors (7-9) have proposed that rotator cuff injury could also result from what was termed secondary impingement. Secondary mechanical impingement results from glenohumeral instability caused by stress and fatigue placed on the static and dynamic stabilisers of the shoulder. Considering that swimmers average 8000-12000m/day, practice 2x/day, 5-7 days/week cumulating on average 9900 stokes per week per shoulder for males and up to 16500 strokes per week per shoulder for females, enormous demands are being placed on the shoulder complex (2, 10-12).

Warner et al (13) found significant dysfunction in scapulothoracic motion in patients with glenohumeral instability and impingement. The two muscles that were identified as having significant weakness were the upper trapezius and serratus anterior. Although whether

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Table 1. Stages of impingement lesions

STAGE	REPRESENTING
1	Oedema and haemorrhage
2	Fibrosis and tendinitis
3	Tears of the rotator cuff, biceps ruptures and associated bone changes like traction spurs, narrowing of the acromiohumeral distance and erosion of the anterior acromion.

scapulothoracic dysfunction was the cause or the result of the instability and or impingement was not determined. It should be noted that the subjects used in the study were not elite swimmers.

Another possible contributing factor to shoulder dysfunction is the muscular imbalance seen in elite swimmers. Over development of the pectoralis major and latissimus dorsi muscles and weakness of both scapular retractors (rhomboids, middle trapezius, and upper fibres of latissimus dorsi) and external rotators (posterior deltoid, infraspinatus and teres minor) sets up an abnormal force couple about the shoulder complex. Also seen in the elite swimmer is overdevelopment of the anterior cervical muscles compared to the posterior muscles. This muscular imbalance is evident in the typical swimmer's posture of rounded shoulders, winging of the scapula and a forward head position (14). Becker commented that an anterior positioned scapula would reduce the efficiency of pectoralis major and latissimus dorsi. Also scapula retraction is needed for clearance of the humeral head and the acromion. Thus a weakness in the strength and endurance of the scapular retractors will decrease performance and increase the chance of overuse syndromes developing (14). A similar pattern of muscular imbalance has been described by Janda (15), and is termed upper crossed syndrome. This syndrome identifies pairs of muscles where one is typically weak and the other typically tight. Some of the combinations include short pectorals and weak serratus anterior producing round shoulders and winging of the scapula. Also short upper trapezius and levator scapulae and weak lower and middle trapezius are pairs that typically occur. Janda was not talking specifically about the typical swimmer's posture with upper crossed syndrome, however the clinical implications are significantly relevant. Fu et al (8) described that the end result of impingement from whatever cause was rotator cuff tendinitis.

There seems to be three clinical syndromes present in shoulder pain of elite swimmers: instability, impingement and tendinitis. From the above research a logical progression of shoulder dysfunction may be one where instability causes impingement which causes tendinitis (16). The instability is set up by stress and fatigue of the static and dynamic structures and also a muscular imbalance similar to upper crossed syndrome. The instability causes a loss of control of the humeral head as it passes under the acromion. This results in impingement and then cuff tendinitis (17). Another progression of

events could be that impingement is due to excessive repeated overhead activity and possibly a faulty stroke which causes tendinitis. The instability could simply be due to swimmers having too much flexibility. Whatever the chain of events there is most likely a combination of all three clinical entities present in a painful shoulder. The presence of dysfunction snowballs and contributes to further dysfunction. The astute clinician may be able to identify which clinical syndrome is the primary cause and thus focus treatment onto one thing, however treating all the syndromes together may give the athlete the best chance of recovery. With an ever increasing understanding of the aetiology of shoulder pain in elite swimmers, more effective treatment and rehabilitation programs can be instigated.

TREATMENT AND REHABILITATION

Treatment of the elite swimmer who has shoulder pain focuses initially on reduction of pain and inflammation and restoration of full pain free range of motion. Once this has been achieved restoration of the normal biomechanics of the shoulder complex is undertaken. Initial treatment has included rest, ice, ultrasound, massage, injections, transcutaneous nerve stimulation, short course of oral anti-inflammatory medication, avoidance of aggravating factors in training or modification of them so they do not cause pain. McMaster and Troup (1) found that with a group that was currently experiencing pain, stretching, resistance training, use of a kickboard (as the shoulder is in a position of flexion and abduction which is an impingement position), and the use of hand paddles all aggravated their pain as they all place increased demands/resistance on already damaged structures. When the pain has subsided or ranges of pain free motion are identified treatment includes daily range of motion exercises, stretching shortened muscles to improve flexibility (pectoralis major and latissimus dorsi), strengthening (see Table 2), endurance training, proprioception utilising upper extremity plyometric exercises, altering training to decrease distance and focus on adequate warm up, increase rest to reduce fatigue, and a gradual return to normal training levels. Arthroscopy, division of the coracoacromial ligament and anterior acromioplasty, anterior capsulolabral reconstructions are the surgical alternatives if a significant course of conservative treatment fails to resolve the symptoms (2, 3, 8, 19-22).

Jobe and Pink (20) proposed rehabilitation of shoulder dysfunction in the overhead athlete to include the four P's (Table 2).

Protectors and Pivoters are rehabilitated first, followed by Positioners and finally Propellers. Strengthening begins first with isotonic followed by isometric exercises. To make this specific to swimming, the Propeller muscles

Table 2. The four P's in shoulder rehabilitation

P's	Represented by
glenohumeral Protectors	Rotator cuff
scapular Pivoters	Especially serratus anterior
humeral Positioners	The three heads of the deltoid
Propeller muscles	Pectoralis major and latissimus dorsi

would need to be stretched rather than strengthened. The Pivoters would need to additionally include the trapezius and rhomboids.

Litchfield et al (21) described that basic rehabilitation of the shoulder needed to consider certain guidelines (Table 3).

Table 3. Rehabilitation guidelines

Rehabilitation should consider the following	
1	Exercises should be done in or anterior to the scapular plane thus placing them in a more functional plane of motion
2	To reduce torque about the shoulder exercises should be carried out with a bent elbow with resistance close to the body
3	Exercises that promote scapular stability should also be performed *
4	At the end of the rehabilitation program initiate sports specific exercises
5	All exercises are to be done pain-free as much as possible to reduce the risk of further injury
6	Perform passive followed by active exercises with stretching into restricted ranges of motion (elevation, internal and external rotation) then strengthening, especially of the cuff and scapular stabilisers (shoulder shrugs, upright rows, and wide gripped seated rows)
7	Strengthening should include both concentric and eccentric contractions in a slow and controlled manner
8	Gradual return to sport

* Examples of exercises that promote scapular stability include closed chain exercises where the scapula is placed in its normal position thus allowing the cuff to work at compressing the GHJ. Exercises begin at degrees below 90 and progress to 90 degrees as the patient progresses. With the hand placed on a wall and the elbow extended, the scapula is moved through patterns of protraction and retraction, elevation and depression, then selective elevation of the acromion. Isometric contractions of the rotator cuff are started early with the scapula retracted and depressed to its normal position, with the patient concentrating on compressing the joint. Later, advanced closed chain exercises are performed including various forms of push ups and scapular stabilisation exercises (18). Kibler (18) also believes that as the cuff operates as a unit then it should be rehabilitated as a unit and not in isolation.

Once a successful treatment and rehabilitation program has been completed the focus changes to prevention. Stopping an injury from returning or happening in the first place is by far better than having to treat it when it does occur.

PREVENTION

An attempt by many researchers to understand what is normal, and what is abnormal biomechanics for the elite swimmer's shoulder has seen improved preventative measures added to their training programs. Freestyle has been reviewed more often because this stroke is used in training 80% of the time regardless of the swimmers competition swimming event (2, 23).

Pink et al (24) studied the normal biomechanics of the shoulder in freestyle swimmers and found that in the pull through phase the first 90 degrees of adduction and extension of the humerus after hand entry is performed by pectoralis major. Teres minor also fires to balance the internal rotation force of pectoralis major and it also may help extension. Latissimus dorsi continues the extension past 90 degrees. The humerus is also internally rotating,

caused by the firing of latissimus dorsi and subscapularis. Serratus anterior is active throughout the whole pull through phase to help propel the body forward and position the scapula. During the recovery phase the posterior deltoid contracts to lift the shoulder out of the water as latissimus dorsi finishes contracting, thus completing the pull through phase. As the humerus is abducted and flexed by supraspinatus, anterior and middle deltoid, positioning of the glenoid fossa for the humeral head is achieved by serratus anterior, upper trapezius and the rhomboids. Infraspinatus fires to counteract subscapularis. All these muscles work in concert to correctly position the shoulder for hand entry. Subscapularis and serratus anterior are active throughout the whole cycle. Pink et al (24) noted that it would appear that these muscles were susceptible to fatigue.

Scovazzo et al (25) compared these results to swimmers with painful shoulders. They found a decreased firing of upper trapezius, rhomboids, anterior and middle deltoid during recovery. Subscapularis also showed significant decrease in activity during recovery. Infraspinatus showed increased activity at the end of pull through and early recovery. Serratus anterior was not as active, whereas the rhomboids were more active during pull through. Latissimus dorsi, pectoralis major, posterior deltoid, supraspinatus, teres minor showed no significant difference in firing between painful and non painful shoulders. Scovazzo et al (25) interpreted these results by saying to avoid the position of impingement for the shoulder which is flexion and internal rotation the firing pattern of the muscles was altered. Infraspinatus worked harder to externally rotate the humerus, anterior and middle deltoid fired less to reduce abduction and forward flexion. Reduced abduction and forward flexion required less activity of upper traps and rhomboids during recovery to position the scapula for the head of the humerus. This combination of muscle activity resulted in the elbow being closer to the water and the hand entering further from the midline. There was an increased firing of the rhomboids which peaked in late pull through to prepare the shoulder for an early hand exit. An early exit avoids the extremes of internal rotation seen with a fully extended elbow as the hand passes the thigh in the normal shoulder. Thus the hand exited the water before passing the thigh and with the elbow bent. The subscapularis fired less during recovery to avoid internal rotation.

Many studies have been done to determine the relationship between strength ratios, and range of motion specifically that of internal versus external rotation. Warner et al (26) identified posterior capsular tightness and a relative weakness of external rotation as physical findings in impingement syndrome. Excessive external rotation and a relative weakness of the internal rotators were found in anterior instability. This research indicates that athletes with impingement need stretching of the posterior capsule

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and strengthening of the external rotators. Those with anterior instability require strengthening of internal rotators and exercises to address excessive external rotation. Work by Warner et al (13) strongly suggests the scapulothoracic muscles especially upper trapezius and serratus anterior need attention in a prevention program.

McMaster et al (27) completed research on elite swimmers and controls without shoulder pain. Their results showed an increase in internal rotational strength and increase in adduction in competitive swimmers compared with same aged college men and women. This resulted in higher adduction:abduction torque ratios and a decrease in external:internal torque ratios. Both groups did not have shoulder pain. The authors concluded that the difference was due to the changes caused by long term swimming which emphasises internal rotation and adduction. The paper by McMaster did not investigate the possibility that this alteration of torque values could produce shoulder problems. If such shoulder pain was to eventuate then a rehabilitation or prevention program was proposed that would include strengthening of the external rotators and abductors.

By contrast to the work of McMaster and Warner (1, 13, 26, 27), Beach et al (10) found no significant correlation between shoulder flexibility, internal:external or abduction:adduction strength ratios and shoulder pain. Correlation was found between the endurance ratios of external rotation and abduction and shoulder pain. As the endurance ratios decreases shoulder pain increased. This suggests that external rotation and abduction endurance needs to be increased in order to reduce the likelihood of shoulder pain.

Bak and Magnusson (28), and Bak and Fauno (29) found that there was a decrease in internal rotational strength in elite swimmers with shoulder pain compared with elite swimmers without shoulder pain. This change in strength was such that external:internal rotational torque ratios was significantly increased. The pain was of a degree to effect performance but not stop training. They suggested that as a result, the rehabilitation of swimmers with mild shoulder pain should include improving internal rotational strength.

It is evident that some of these studies contradict each other. However the research indicates that a certain number of factors are needed in the prevention of swimmer's shoulder in the elite athlete. It seems evident that strength and endurance training is required for subscapularis and serratus anterior as they are susceptible to fatigue from continuously firing throughout the cycle. Strength and endurance training is also needed for the external rotators and abductors. Research by Warner suggests that of the scapulothoracic muscles that need strengthening it is the upper trapezius and serratus anterior

that require the most work. However failure to promote some rehabilitation of the rhomboids, middle and lower trapezius seems detrimental to a healthy shoulder complex. Of research into the proper length of active and passive structures, stretching a tight posterior capsule seems to give the greatest benefit to the elite swimmer.

CONCLUSION

Due to repetitive nature of swimming, elite athletes are prone to develop overuse injuries. Swimming subjects the shoulder complex to stresses that alter the normal biomechanics of the joint and predispose it to injury. With such a high prevalence of shoulder pain experienced by elite swimmers much research has gone into understanding the aetiology of its cause. Tendinitis, impingement, instability, scapulothoracic dysfunction and muscle imbalances have all been implicated to be the cause, or part of the cause of shoulder pain in elite swimmers. Treatment and rehabilitation of swimmer's shoulder focuses on restoring the normal biomechanics of the shoulder complex. Preventative measures are aimed primarily to improve the strength and endurance of subscapularis, deltoid, serratus anterior, teres minor, infraspinatus, trapezius and rhomboids. Further research and understanding of the aetiology, treatment and rehabilitation, and prevention of shoulder pain in elite swimmers provides the best means to keep them performing at their peak.

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