The Swimmer's Shoulder: Multi-directional Instability

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Abstract

Purpose of Review Swimmer's shoulder is the term used to describe the problem of shoulder pain in swimmers. Originally described as supraspinatus tendon impingement under the coracoacromial arch, it is now understood that several different pathologies can cause shoulder pain in competitive swimmers, including subacromial impingement syndrome, overuse and subsequent muscle fatigue, scapular dyskinesis, and laxity and instability.

Recent Findings Swimmers may develop increased shoulder laxity over time due to repetitive use. Such excessive laxity can decrease passive shoulder stability and lead to rotator cuff muscle overload, fatigue, and subsequent injury in order to properly control the translation of the humeral head. Generalized laxity can be present up to 62% of swimmers, while a moderate degree of multi-directional instability can be present in the majority. Laxity in swimmers can be due to a combination of underlying inherent anatomical factors as well as from repetitive overhead activity.

Summary The role of excessive laxity and muscle imbalance are crucial in the swimmer's shoulder and should be well understood since they are the primary target of the training and rehabilitation program.

Keywords Swimmer's shoulder · Shoulder pain · Shoulder · Laxity · Instability · Rotator cuff

Introduction

Swimmer's shoulder is the term used to describe the problem of shoulder pain in swimmers. Kennedy and Hawkins coined this term in 1974 to describe supraspinatus tendon impingement under the coracoacromial arch caused by the repeated shoulder abduction and forward flexion required during free-style and butterfly swimming strokes [1]. These authors found a prevalence of 3% of shoulder pain in competitive swimmers in the 1970s [2], whereas more recently, the literature reports the prevalence to be as high as 91% [3–9], representing the most frequent musculoskeletal injury in competitive swimmers. Shoulder pain in competitive swimmers can be caused by many different etiologies including subacromial impingement syndrome, overuse and subsequent muscle fatigue,

scapular dyskinesis, laxity and instability, labral damage, os acromiale, and suprascapular neuropathy [10]. The incidence of shoulder pain in swimmers is generally proportional to the age, years of training, and the level of competition [11].

The purpose of this review is to provide an overview of the biomechanics of swimming, the etiology of the shoulder pain, and the role of multi-direction instability in shoulder pain in swimmers.

Swimming Biomechanics

Swimming is an unusual sport in that the shoulders and upper extremities represent up to the 90% of the propulsive power, and requires several different shoulder motions, most being performed in clockwise and counter-clockwise directions with varying degrees of internal and external rotation and scapular protraction and retraction [12]. There are four different types of strokes: freestyle or front crawl stroke, backstroke, breaststroke, and butterfly stroke. However, regardless of the stroke specialty, the training is principally in freestyle stroke [1,13–15].

The power of freestyle stroke comes 80% from the pull and 20% from the kick [16]. The freestyle can be divided in six parts: hand entry, forward reach, pull-through, middle pull-

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through, hand exit, and middle recovery [10•]. During the hand entry and the beginning of the pull phases, the shoulder is in forward flexion and the humerus is in abduction and internal rotation [16]. The pull-through represents the phase during which the most force generation occurs [17] (Fig. 1). The end of the pull is characterized by the extension of the shoulder with the humerus in adduction and internal rotation [16]. During the recovery phase, the humerus is in abduction and internal rotation, moving from extension to flexion with the arm out of the water [16].

There are small differences within the other styles, in which the contribution from the pull to the power of the stroke is different: 50% for breaststroke, 70% for butterfly, and 75% for backstroke [16].

Pink et al. performed a detailed electromyographic and cinematographic study of the normal freestyle stroke and studied the differences between painful and non-painful shoulders [17,18].

The pectoralis major and latissimus dorsi were the most active muscles during the initial powerful adduction and extension of the humerus. When the humerus is perpendicular to the body, the latissimus dorsi continues the pulling, while the serratus anterior works to move the body over the arm and rotate the scapula upwardly to maintain the glenohumeral congruency. When the latissimus dorsi finishes its activity, the posterior deltoid lifts the shoulder out of the water. Middle and anterior deltoid, rhomboids, supraspinatus, and trapezius muscles are involved in the recovery phase of the stroke to stabilize the scapula and the humerus. The authors highlighted that the serratus anterior and the subscapularis are the muscles more prone to fatigue since they continually fire above 20% of maximal manual muscle test (MMT) [17].

When the authors looked at the differences between painful and non-painful shoulders, they found that the serratus anterior action is dramatically reduced during the middle pull-through phase, with a consequent compensatory action of the rhomboids, resulting in scapular destabilization [18]. Similar to the serratus anterior, the subscapularis is susceptible

Fig. 1 Swimmer during the pull-through phase (backstroke)

to fatigue because of its continual activity with a consequent compensatory activity of the infraspinatus resulting in unbalanced glenohumeral stabilization [18].

Swimmers with pain during internal rotation may drop the elbow during the recovery phase of the freestyle stroke, reducing the rotational demand, diminishing the pain, and entering the water with a wider hand entry [18]. Swimmers with shoulder pain may also have excessive body roll and winging of the scapula as signs of a painful shoulder [18].

Etiology of shoulder pain

Shoulder pain in competitive swimmers can be caused by many different etiologies including subacromial impingement syndrome, overuse, scapular dyskinesis, laxity and instability, labral damage, os acromiale, and suprascapular neuropathy [10•].

Originally, Kennedy and Hawkins [1] proposed that the cause of the shoulder pain was due to repetitive impingement of the avascular zone of the insertion of the supraspinatus and the intracapsular portion of the bicipital tendon under the coracoacromial arch during the adducted position of the shoulder (outlet impingement). Other reports suggested that the impingement was produced by instability or muscle imbalance of the scapula stabilizers [16,19,20]. However, with continuing analysis of shoulder pain, it became evident that the cause may be multifactorial, including overuse and fatigue of muscles of the shoulder, laxity and instability, and biomechanics of the swimming stroke [21–23].

Overuse

Competitive swimmers may swim up to 9 miles per day, completing 2500 or more shoulder revolutions per day [18, 21]. This type of training predisposes swimmers to overuse injuries of the shoulder. Subscapularis and serratus anterior are active during the majority of the pull-through phase and thus are prone to fatigue [17, 18]. As these muscles fatigue, shoulder kinematics is adversely affected, often leading to secondary impingement.

Impingement

Subacromial impingement in competitive swimmers is typically caused by altered kinematics (non-outlet impingement) due to muscle fatigue or laxity [21]. Shoulder range of motion (ROM) in swimmers is similar to that of other overhead athletes, with some athletes demonstrating adaptive changes including limited internal rotation and excessive external rotation. Failure of the rotator cuff tendons and scapula stabilizers to maintain centering of the humeral head in the glenoid fossa can lead to excessive humeral head translation with subsequent impingement [24,25]. Impingement can be subacromial

or intra-articular and may occur in various positions during the swimming stroke [21]. In the subacromial impingement, the bursal side of the rotator cuff impinges against under the coracoacromial arch with the arm in forward flexion, and internal rotation (recovery phase of the stroke), while in the intra-articular impingement, the biceps tendon or the articular side of the rotator cuff tendons impinges against the anterosuperior margin of the glenoid and labrum with the arm in forward flexion, adduction, and internal rotation (hand entry phase of the stroke) [21]. Impingement can be exacerbated by any process that alters shoulder kinematics, such as scapular dyskinesis, excessive joint laxity, and muscle fatigue [26].

The relationship between impingement and glenohumeral laxity was first proposed by Jobe et al. [27]. They hypothesized that repetitive and forceful overhead activities can cause a gradual stretching of the anteroinferior capsuloligamentous structures due to the chronic microtrauma, with subsequent increased laxity and instability that leads to a mechanical impingement [27]. Despite the lack of support of this hypothesis in the literature, supraspinatus tendinopathy was identified by Sein et al. [9] as an important cause of shoulder pain in swimmers.

Scapular Dyskinesis

Scapular protraction is a common sign of scapular dyskinesis in swimmers [28]. When the serratus anterior and subscapularis fatigue, the unopposed pectoralis major strains the anterior glenohumeral joint and may lead to an abnormal scapular motion, narrowing of the subacromial space, and consequent impingement [29–32]. Labral deformities and pain can be the final result of the chronic scapular dyskinesis [30]. Scapular dyskinesis can also lead to suprascapular nerve entrapment when it is coupled with hyperelasticity and infraspinatus contraction [10•]. Symptomatic nerve entrapment can occur when the subacromial space is already reduced by the chronic microtrauma-induced thickening of the supraspinatus tendon and adjacent bursa [10•].

Glenohumeral Internal Rotation Deficit

Burkhart et al. [33] defined the glenohumeral internal rotation deficit (GIRD) as “the loss in degrees of glenohumeral internal rotation of the dominant shoulder compared with the nondominant shoulder”. Torres and Gomes [34] found that the mean internal rotation in competitive swimmer was $12^\circ \pm 6.8^\circ$, demonstrating that the capsule and/or rotator cuff are tighter posteriorly. The loss of internal rotation and the gain in external rotation in competitive swimmers is associated with an anterior shift of the humeral head with consequent instability of the capsule and impingement [32,33,35]. The possible

explanation of this unilateral pathology can be the preference of the swimmers to breathe on their dominant side, which requires extra external rotation [36,37].

Os Acromiale

Os acromiale was reported to be a cause of shoulder pain in swimmers [38,39]. Although relatively uncommon, this condition can mimic the impingement syndrome and may be associated with shoulder tenderness. Os acromiale is important to include in the differential diagnosis of shoulder pain since the prevalence in the general population is between 1 and 15% [39].

Laxity and Multi-direction Instability

Excessive translation of the humeral head on the glenoid is normally prevented during athletic activities by the static stabilizers of the glenohumeral joint (glenoid labrum and capsular ligaments), as well as the dynamic stabilizers (rotator cuff and scapular muscles). It is well-established that there is a narrow distinction between physiologic laxity (normal) and pathologic instability (abnormal). Normal laxity may be increased over time with repetitive overuse and can eventually become pathologic [22]. Glenohumeral laxity can be advantageous for swimmers up to a certain point, allowing a greater stroke length with a consequent increase in speed and efficiency [13,21]. However, the decreased passive stability provided by the static stabilizers necessitates a greater contribution of the active stabilizers in order to properly control the translation of the humeral head and glenohumeral kinematics [21]. An imbalance due to excessive laxity can lead to cuff muscle overload, fatigue, and subsequent injury [13,40]. Previous studies have documented the presence of increased joint laxity and glenohumeral instability in competitive swimmers [4,18,23]. Bak and Faunø [4] found that increased humeral head translation with associated apprehension was present in 75% of competitive swimmers. Pink and Tibone [18] reported that generalized ligamentous laxity is present in 20% of competitive swimmers. Similarly, Zemek and Magee [23] reported both increased glenohumeral laxity and increased generalized joint hypermobility in competitive swimmers. More recently, Rodeo et al. [40] found that a moderate degree of laxity was present in all the 42 Olympic swimmers (84 shoulders) that were evaluated. The authors found that the humeral head could be translated to the glenoid rim in most patients, with similar degrees of anterior and posterior translations. Inferior laxity (positive sulcus sign) of 1 to 2 cm was present in 98% of the shoulders (82 of 84). Generalized laxity was found in 62% of swimmers [41•], a definitely higher prevalence compared to the study of Pink and Tibone [18]. These studies suggest that a combination of acquired and inherent factors contribute to shoulder laxity in swimmers [42•].

Conclusions

The cause of shoulder pain in swimmers should be considered multifactorial, including overuse and fatigue of muscles of the shoulder, laxity and instability, and biomechanics of the swimming stroke. Despite the fact that shoulder pain can be clinically present as subacromial impingement, it is typically caused by altered kinematics (non-outlet impingement) due to muscle fatigue or laxity. The role of excessive laxity and muscle imbalance are crucial in the swimmer's shoulder and should be well understood since they are the primary target of the training and rehabilitation program.

Compliance with Ethical Standards

Conflict of Interest Both authors declare that they have no conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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