Subacromial Impingement in Competitive Swimmers

A Systematic-Review

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Abstract

Objective: To compile and research on the causation of subacromial impingement in competitive swimmers.

Methods: A computer-assisted literature search of PUBMED, Cochrane and Google Scholar. Because of lack of articles investigating hypothesis, finding only two, quality assessment of both quality of article as well as quality of hypothesis was conducted.

Results: Twenty-four articles were critiqued with 14 showing acceptable quality. Rotator cuff muscle imbalance, posterior capsule tightness and scapular dyskinesis were identified as causative factors with high evidence. Subacromial impingement is caused by factors such as anterior instability, biceps pathology, deficits of neuromuscular control due to GIRD, rotator cuff tendinitis and labrum lesions and bursitis. Aspects such as acromial morphology, training errors, hypovascularity and glenohumeral laxity are controversial causative factors.

Conclusion: Current research shows limited evidence. Based on pooled data, the causation of subacromial impingement is multifactorial and implicates that development of impingement aggravates the underlying factors.

Keywords: subacromial, impingement, causation, cause, competitive, elite, swimmers, injury, swimming

Introduction

Shoulder pain frequently causes professional swimmers to miss training sessions and the interferes with competitions. Epidemiological studies report that 40 – 70 % of professional swimmers complain of shoulder pain (Yanai et al.). In 1972 Neer introduced the term impingement and in 1977 Neer and Welsh coined the term Swimmer’s Shoulder identifying subacromial, secondary impingement as main factor leading to shoulder pain. Impingement was described as a mechanical compression of the rotator cuff and the subacromial bursa against the anterior acromion and the coracoacromial ligament from below, especially during elevation of the arm. Repetitive elevation is carried out by overhead athletes and leading to impingement during several phases of the swim specific motions (Yanai et al.). Primary impingement was defined as a mechanical obstruction of the rotator cuff tendons under the
anterior inferior one-third of the acromion, the coracoacromial ligament, and sometimes the acromioclavicular joint while secondary impingement was generally defined as a relative decrease in subacromial space as a result of glenohumeral instability (Allegrucci et al.). In recent literature the cause for secondary impingement is hypothesized to be overuse (Thomas et al.), glenohumeral instability (Pink et al., Jobe et al.), scapular dyskinesis (Cools et al., Borsa et al.), rotator cuff or biceps pathology (Lo et al., Bansal et al.) or an internal rotation deficit of the glenohumeral joint (Cools et al., O'Donnell et al.).

The purpose of this study is to clarify the cause of subacromial impingement in professional swimmers.

**Methods**

**Research Process**

The online search engines Pubmed, Cochrane, Google Scholar and reference lists of obtained articles were searched to obtain articles. A preliminary search using the search terms swimmer and shoulder injury was performed revealing 1520 articles matching the search terms. A second, more specific search revealed 107 articles. The search terms were impingement, cause, injury, swimmers, swimmer injury, shoulder injury swimmer cause elite, shoulder pain cause swimmers elite injury, swimmer shoulder, shoulder injury and swimmers, impingement and swimmers. Inclusion criteria were a publication date after 1990, articles written in the English language, the subjects had to be competitive swimmers or overhead athletes and the article had to mentioned impingement syndrome or shoulder instability. 13 articles could not be retrieved due to lack of funds. Furthermore, articles neither including swimmers nor discussing the causation of impingement syndrome were excluded, leaving 20 articles for grading to allow a final selection of articles for the review.

**Inclusion and Exclusion**

The articles that were accepted from the general criteria were graded using two questionnaires, one to grade the quality of cause-and-effect assumption (15 questions with a maximum of 39 points), and the second was the grading of the quality of the articles itself (35 questions with a maximum of 70 points).

In order to ensure quality of the inclusion criteria the concept for the inclusion questionnaires were derived them from three separate articles (Hill et al 2005, Philip B et al 2001, West et al 2002). These questionnaires were inserted into a Digital Questionnaire Platform so the results were immediately introduced into an excel file to ensure all data was synoptic. After both forms were filled in the combination of the two grades were made, the quality of cause and effect counted for 33% of the grade and the general quality of the article counted for 66% of the grade. Any articles that received less than 50% of the maximum grade (170 points max, thus 85 points or lower) were excluded from the systematic review. Each article was reviewed by two separate evaluators, any discrepancies between the score given by the evaluators were discussed, and then graded by a third evaluator. The average score of the three grades was then taken to achieve a final grade for the article.

In total 14 high quality and specific articles we accepted to this systematic review. These articles have been place in table 2 of the results section in order of the highest overall score and evidence to the lowest. Hypotheses’ related to our Research Question were extracted from each article and have been included in table 2 (see Results section) in order to portray the strength of the statement. Extracting of these hypotheses was performed by 2 researchers and then synthesized into one statement as listed in table 2.

**Results**

**Excluded studies**

Articles were excluded when not addressing the target population or not address impingement in the population. One article was excluded because it was concerned with primary impingement (Bedi et al, 2009). Due to scores below 0.5, 6 articles were excluded (Fowler 0.35 (0.08, 0.49), Johnson 0.45 (0.07, 0.64), Lo 0.29 (0.3, 0.28), O'Donnell 0.46 (0.14, 0.62), Pieper 0.39 (0.29, 0.44), Ramsi 0.41 (0.4, 0.41).
Study characteristics

In total, 14 articles were included in the systematic review. Those included 1 cohort study (Thomas), 1 diagnostic study (Brushøj), 10 case-studies (Borsa, Bansal, Yanai II, McKim, Cools I, Cools II, Thomas, Jobe, McMaster) and 3 experts opinions (Allegrucci, Yanai I, King). The year of publication ranged from 1990 to 2009. 5 articles were published before 2000 (Allegrucci, Jobe, King, McKim, McMaster) with an average score of 0.62, 5 between 2000 and 2005 (Blanch, Borsa, Cools I, Yanai I, Yanai II) with an average score of 0.69, and after 2005 4 were published (Thomas, Cools II, Brushøj, Bansal) with an average score of 0.67.

In the listing of the detailed scores, quality of article scores were listed first followed by the quality of hypothesis-scores: Allegrucci (0.22/0.68), Bansal (0.49/0.62), Blanch (0.23/0.95), Borsa (0.51/0.88), Brushøj (0.38/0.62), Cools I (0.49/0.83), Cools II (0.76/0.9), Jobe (0.35/0.78), King (0.26/0.64), McKim (0.71/0.82), McMaster (0.22/0.82), Thomas (0.66/0.46), Yanai I (0.73/0.49), Yanai II (0.4/0.87).

The article of Blanch had the highest score in hypothesis elaboration and third lowest in overall quality assessment of article, therefore showing with 0.74 the largest difference in that respect. 9 articles scored in quality of article under 0.50 and hypothesis elaboration above 0.6 including Allegrucci, Bansal, Brushøj, Cools I, Jobe, King, McMaster and Yanai II. 2 articles scored in quality of article above 0.6 and hypothesis elaboration below 0.5: Thomas and Yanai I. Highest combined scores were received by Borsa, McKim and Cools II with McKim and Cools II showing the highest level of evidence. Hypotheses extraction was performed by 2 researchers and then synthesized into one statement as listed in table 2.
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<th>Author (yr)</th>
<th>Hypothesis</th>
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| McKim (1998) | - Secondary impingement in the adult swimming athlete is caused by Posterior capsule tightness, glenohumeral joint laxity and rotator cuff muscle imbalance. Overwork and scapulothoracic dysfunction are secondary factors causing impingement. (p. 52)  
- Acromial morphology, training errors and hypovascularity do not cause secondary impingement. (p.104) | 0.79 | 3b |
| Yanai (II) (2000) | - Secondary impingement is caused by the position of the glenohumeral joint in the recovery phase of freestyle swimming. (p.30)  
- Hand paddles aggravate secondary impingement (p.30) | 0.71 | 3b |
| Cools et al. (II) (2007) | - Secondary impingement in the adult overhead athlete is caused by glenohumeral instability, rotator cuff or biceps pathology and scapular dyskinesis including serratus anterior dysfunction. Scapulothoracic muscular dysbalance causes impingement in the glenohumeral joint. (p.25, 31f)  
- Functional instability may aggravate the underlying instabilities and create a cyclic aggravation of impingement resulting in chronic shoulder pain. (p. 25) | 0.85 | 4  |
| Borsa et al. (2005) | - Secondary impingement in the adult overhead athlete is not caused by glenohumeral laxity.  
- Secondary impingement is caused by eccentric tensile overload of the supraspinatus tendon and mechanical impingement secondary to fatigue-induced dyskinesis. Impairment of humeral dynamic stabilizers, inability of the scapular muscles to upwardly rotate and posteriorly tilt the scapula may cause impingement. (p.1083) | 0.76 | 4  |
| Thomas et al. (2009) | - Secondary impingement is caused by repetitive demands placed on the shoulder complex over several years. (p. 230)  
- Chronic eccentric contractions lead to posterior capsular thickening and GIRD, leading to muscular imbalance and increase in external rotation, resulting in changes in neuromuscular control resulting in secondary impingement. (p. 235) | 0.65 | 4  |
| McMaster et al. (1998) | - Secondary impingement in the adult competitive swimmer is caused by multidirectional shoulder laxity resulting in superior migration of the humeral head. (p.83) | 0.62 | 4  |
| Bansal et al. (2007) | - Secondary impingement in the adult competitive swimmer is caused by atraumatic anterior instability, rotator cuff tendinitis, rotator cuff fatigue, scapulothoracic dysfunction and hypovascularity of the supraspinatus tendon due to repetitive actions of swimmers. (p. 105f) | 0.58 | 4  |
| Brushøj et al. (2007) | - Secondary impingement in the adult overhead athlete is caused by superior labrum, anterior to posterior (SLAP) lesions, bursal-side tears of the supraspinatus tendon, impingement of the posterior rotator cuff and inflammation of the long head of the biceps tendon. (p. 373)  
- Dysbalance/Dysfunction of the scapulothoracic stabilizers as well as rotator cuff impairment contributes to secondary impingement. (p.376) | 0.54 | 4  |
| Cools et al. (I) (2004) | - Secondary impingement in the adult overhead athlete is caused by shoulder instability, posterior capsule tightness and scapulothoracic weakness resulting in functional shoulder instability. (p.64)  
- Functional instability may aggravate the underlying instabilities and create a cyclic aggravation of impingement resulting in chronic shoulder pain. (p. 64) | 0.72 | 5  |
| Blanch (2004) | - Secondary impingement in the adult competitive swimmer is caused by shoulder instability, posterior capsule tightening, hyperangulation and rotation of the glenohumeral joint due to lack of flexibility or hypermobility resulting in excessive translation of the humeral head. (p. 112f) | 0.71 | 5  |
### Discussion

**Principle findings**

The results suggest that the causes for development of impingement in swimmers are multi factorial. Several factors of anatomic, biomechanical and neuromuscular nature coupled to the particular requirements of the swim sport are thought to coincide leading to impingement. Moreover, a cyclic development is proposed. This implies that secondary impingement, caused by instability and other factors, furthermore provokes the aggravation of anticipated factors. The investigation of subacromial impingement as a cyclic progressing condition (Cools et al., 2007, Jobe et al., 1993, McKim, 1998) seems appropriate to the research team. Factors such as posterior capsule tightness, rotator cuff muscle imbalance, scapular dyskinesis and scapulothoracic muscle dysbalance (Cools et al., 2007, McKim, 1998) indicate that impingement syndrome in its complexity is not limited to the glenohumeral joint, but rather requires to investigate the whole shoulder complex, including thoracic spine, scapular characteristics and overall muscular balance.

**Interpretation of findings**

Factors contributing to the development of impingement are studied in isolation rather than in combination of their components. This may be due to the complex interaction of factors. The timeline in which development of impingement takes place and the sequence in which factors contribute has yet to be established. Only one of the articles investigated the topic in a longitudinal study (Thomas et al., 2009). Possible contributing psychosocial influences as e.g. peer pressure to assume a certain swim typical posture are not discussed in any of the articles. Additionally, the coach-swimmer-relation as a possible factor (Philippe et al., 2005) aggravating shoulder injury is not properly addressed. A limitation of current evidence is the investigation of hypothesized causative agents. Several studies are conducted to identify associative quantified factors (McMaster et al., 1998, Bak et al., 1997, Miranda et al., 2001, Sein et al., 2008), and only 2 articles could be identified quantifying hypothesized factors (McKim, 1998, Cools et al., 2007). As the majority of articles stated expert’s opinions, a longitudinal study on a well-elaborated hypothesis would be more appropriate. As to the knowledge of the researchers there is no systematic

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<th>Author(s)</th>
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<td>Jobe et al. (1993)</td>
<td>Secondary Impingement of the shoulder in the overhead athlete under the age of 35 is caused by weakened anterior wall muscles that are weak, injured or fatigued. The anterior wall becomes stretched, and the posterior capsule tight. This causes glenohumeral subluxation and this in turn leads to impingement. Rotator cuff tears result from this which aggravates the original instability. (p. 427)</td>
<td>0.64</td>
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<td>Yanai (I) (2000)</td>
<td>Secondary impingement is caused by bursitis and rupture of rotator cuff tendons (p.21) - Shoulder pain in competitive swimmers is caused by subacromial impingement. (p. 21)</td>
<td>0.57</td>
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<td>Allegrucci et al. (1994)</td>
<td>Secondary impingement in the adult competitive swimmer is caused by glenohumeral instability. This instability may result because of injured static (labrum, ligament, and capsule) or fatigued or injured active stabilizers or the shoulder joint. - Factors such as acromial morphology, decreased subacromial space, impaired scapular stability and inadequate vascularization of the rotator cuff tendons may be predisposing factors to shoulder injury (p. 309). Furthermore, muscular imbalance and scapulothoracic dysfunction predispose a shoulder to injury (p. 311).</td>
<td>0.53</td>
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<tr>
<td>King et al (1995)</td>
<td>Subacromial impingement is caused by overuse, bony configuration, hypovascularity, muscular imbalance of the shoulder girdle, posterior joint instability, flexibility and stroke technique. (pp.334-336)</td>
<td>0.51</td>
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review written on this topic.

**Evaluation of review**

Since there are no systematic reviews written on this topic up to date, a quality of the present research is investigating available evidence on subacromial impingement in a systematic way. There are only few researches carried out answering to the named hypothesis. Due to the lack of research carried out concerning injury development in swimmers it is currently not possible to supply an evidence based answer to the research question. Some articles applicable to the review could not be retrieved. It is possible that hypothesis about the development of impingement were missed simply because they were stated in articles not meeting the inclusion criteria for this review. Some articles applicable to the review could not be retrieved.

**Appraisal of methodological quality of the review**

After the researchers concluded that no sufficient evidence was to be found concerning the question initially raised, a method was developed to investigate quality of hypothesis elaborated in various articles. This expanded our literature review to expert’s opinions, etc., therefore indicating a widespread research using Google scholar. In the most cases the grading of articles showed coherent results of both researchers assessing an article. The grading of quality of article, however, did not cover every quality of articles because of the great variety of types of articles.

**Applicability of findings**

The hypotheses found in this review were amassed as proposed in contemporary science and therefore, constitute a contribution to science. The results illustrate the gain of specific knowledge for a particular population group. Furthermore, tendencies in science concerning the term impingement itself can be observed. Blanch (2004) points out a change of view on impingement on basis of definitions of the syndrome that make the term impingement and instability nearly interchangeable. Thus, also changes regarding the approach towards impingement are anticipated. Literature clearly states the complexity of the topic and single factors that contribute to the development of impingement were identified, as e.g. scapular instability. This knowledge can serve to develop approaches for injury prevention.

**Conclusion**

**Implications for practice:**

- Subacromial impingement may be caused by factors such as posterior capsule tightness, rotator cuff muscle imbalance, scapular dyskinesis and scapulothoracic muscle dysbalance (3b)
- Subacromial impingement may be caused by factors such as anterior instability, biceps pathology, deficits of neuromuscular control of the shoulder girdle due to GIRD, repetitive demands on the shoulder throughout a professional career and rotator cuff tendinitis, labrum lesions and bursitis. (4)
- The development of impingement may be reciprocal, indicating that the development of impingement aggravates underlying factors.
- Hypothesis about factors such as acromial morphology, training errors, hypovascularity and glenohumeral laxity are contradictory.

**Implications for research:**

- Subacromial impingement consists of a variety of pathologies
- Scientific investigation of hypothesis of causation of impingement in competitive swimmers is limited at this point.
- The development of appropriate quantification of hypothesized causing factors of subacromial impingement is strongly recommended for future research
- A hypothesis needs to integrate or fit the multi-dimensional character of impingement syndrome in competitive swimmers (i.e. biomechanical, sport-specific)

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References

7. Becker, T. Competitive swimming injuries: their cause and prevention 9-38
25. heater, C. Swimming. Department of Physical Education California State University, Chico, CA USA
27. Hill B. The environment and disease: Association and Causation, Bulletin of the world health organization, October 2005; 83 (10)
28. Hill, J Shoulder Injuries: Epidemiology Northwestern University Medical School Chicago, IL, USA
29. Jain K, McLaughlin P. Shoulder strength in amateur swimmers. Victoria University 2005
32. Johnson JN, Gauvin J, Fredericson M, Simming Biomechanics and Injury Prevention, The Physician and Sports Medicine, 2003;31(1)
37. McKim KR, A comprehensive analysis of the swimmer's shoulder, University of British Colombia, 1998
38. McMaster WC, Roberts A, Stoddard T. A Correlation Between Shoulder Laxity and Interfering Pain in Competitive Swimmers, the American journal of sports medicine, 1998; 26; 1
Tendinopathy, British Journal of Sports Medicine (2008),
doi:10.1136/bjsm.2008.047282


