

SHOULDER INJURIES IN SWIMMING

MEETING THE CHALLENGE

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Doha is hosting the 12th FINA World Swimming Championships (25 metres) this month. With the number of keen young competitive and senior recreational swimmers in Doha on the increase, it is important to focus on common swimming injuries and how they relate to training and possible technique errors.

In this clinically-oriented paper, we will provide you with a practical approach to managing common shoulder injuries in swimmers. This paper is aimed at the clinician who understands injury pathology, but is without much experience or training in swimming-specific biomechanics. We'll concentrate on shoulder injury in this article and address other swimming-related injuries in a future edition. The key is an integrated, multidisciplinary approach between the clinicians and the

coaching team. Don't get stuck in the maze of pathology-driven diagnoses and management approaches. Functional and technical aspects – including possible swimming technique errors – are important considerations in the management of swimming injuries. Bear in mind though that currently this approach is largely eminence (not evidence) based.

Swimming is a very technical sport and swimming fast is a highly skilled activity. Similarly, swimming-related injury can be related to technique flaws. We can improve our clinical management by understanding what creates efficiency in the swimming technique and then assessing how the technique of the injured swimmer presenting in your clinic may deviate from this. Typically, most clinicians have little training in the importance of stroke

technique and how it relates to performance and injury.

SWIMMING AND SHOULDER INJURY

Shoulder injuries are the most common injuries in swimming with a prevalence of 47 to 90%¹⁻³. Shoulder pain forces 10 to 31% of swimmers competing at national or international level to stop training for some time^{1,3,4}. A significant number of swimmers have chronic shoulder injuries; these injuries are sometimes career-threatening or even career-ending.

What is the reason for the high prevalence of shoulder injuries in swimmers? There is not enough good quality research for us to be able to make any definitive statements.

A history of previous shoulder injury is one of the few known risk factors for developing another shoulder injury⁵.

WORKING WITH SWIMMERS

Swimmers are a special group of athletes with very specific challenges for the managing clinician.

- They train a lot – often twice a day and for 3 to 6 hours in total. Despite the amount of training, swimmers don't seem to have the same risk of injury we see in other sports such as football, track and field and rugby.*
- Swimmers begin their career earlier than a lot of other sports, typically at an age of 8 to 12 years.*
- The volume of exercise is staggering – up to 1.5 million arm strokes per arm, every year.*
- Unsurprisingly then, they usually suffer from overuse injuries. What is important though, is that they often continue to train despite pain or discomfort. The culture in swimming can be one of tolerating pain. Shoulder injuries are by far the most common injuries seen in swimmers.*
- A clear pathoanatomic diagnosis is often difficult to achieve. The whole 'kinetic chain' seems to be involved with multiple extrinsic and intrinsic contributing factors.*
- Swimmers will expect the managing clinician to have a good knowledge of swimming technique and how that might influence specific injury patterns; clinical care of these athletes will be improved substantially by understanding the demands of competitive swimming.*

It is likely that overload, especially an abrupt increase in relative training load, is important in developing injury. Work in other sports suggest that week-on-week increases in load of up to 10% can largely be tolerated, but increases beyond this are associated with a more-or-less linear increase in injury incidence⁶. Therefore, it's very important in your history to get a thorough idea of the swimmer's recent training history in terms of intensity, duration and type – specifically what swimming they have been doing, including drills, as well as any additional land training. Understanding the role of changed training load in the current injury can help the swimmer, their coach and parents in preventing a similar recurrence.

The resistance to moving through air or water (the 'drag' forces) are proportional to the velocity squared – i.e. double the speed and you quadruple the drag force. The speeds people typically run at are too slow for this to be a practical consideration, but cyclists see real world improvements through improving their aerodynamics. Water is nearly 800 times denser than air

and drag forces are extremely important at all swimming speeds. Hydrodynamic modelling suggests that to swim faster, a swimmer can increase their propulsion force by 30% or reduce their drag by 5% for the same benefit. It's no coincidence that many of the records set while 'fast suits' were legal remain standing years later. Achieving these hydrodynamically efficient swimming positions (long and lean body position, aligned with the direction of travel) while still being able to generate the important propulsive forces require specific strengths, flexibilities and skills. Swimmers will try to increase the length of the propulsive phase (when the arm is in the water), combined with a fast but 'relaxed' recovery phase (above the water). Conversely, if a swimmer is in an inefficient position, their drag force increases, as does the load on their propulsive mechanism – mostly their arms and particularly their shoulders. Modelling studies suggest that, on average, the supraspinatus tendon is in a position of potential mechanical impingement for nearly 25% of the freestyle arm stroke cycle⁷.

The term 'swimmer's shoulder' was introduced by Kennedy and Hawkins⁸. This term is, however, a nondescript and confusing catch-all term which doesn't really advance our understanding. We believe this term should be replaced by an individualised and more specific diagnosis, which accounts for the individual contributing factors (extrinsic and intrinsic) and suspected pathology of each injured swimmer. This will then allow for a more clear approach and tailored treatment. Whatever an individual's preferred stroke is, more than 50% of their training will be spent doing freestyle⁹. We therefore need to have a good understanding of the freestyle swimming stroke.

FREESTYLE TECHNIQUE

The key aims of maximising freestyle performance are to generate a high propulsive force while simultaneously minimising drag through the water. As with most motor patterns, there is variation in technique between individual swimmers. Biomechanists divide the freestyle stroke into five phases:

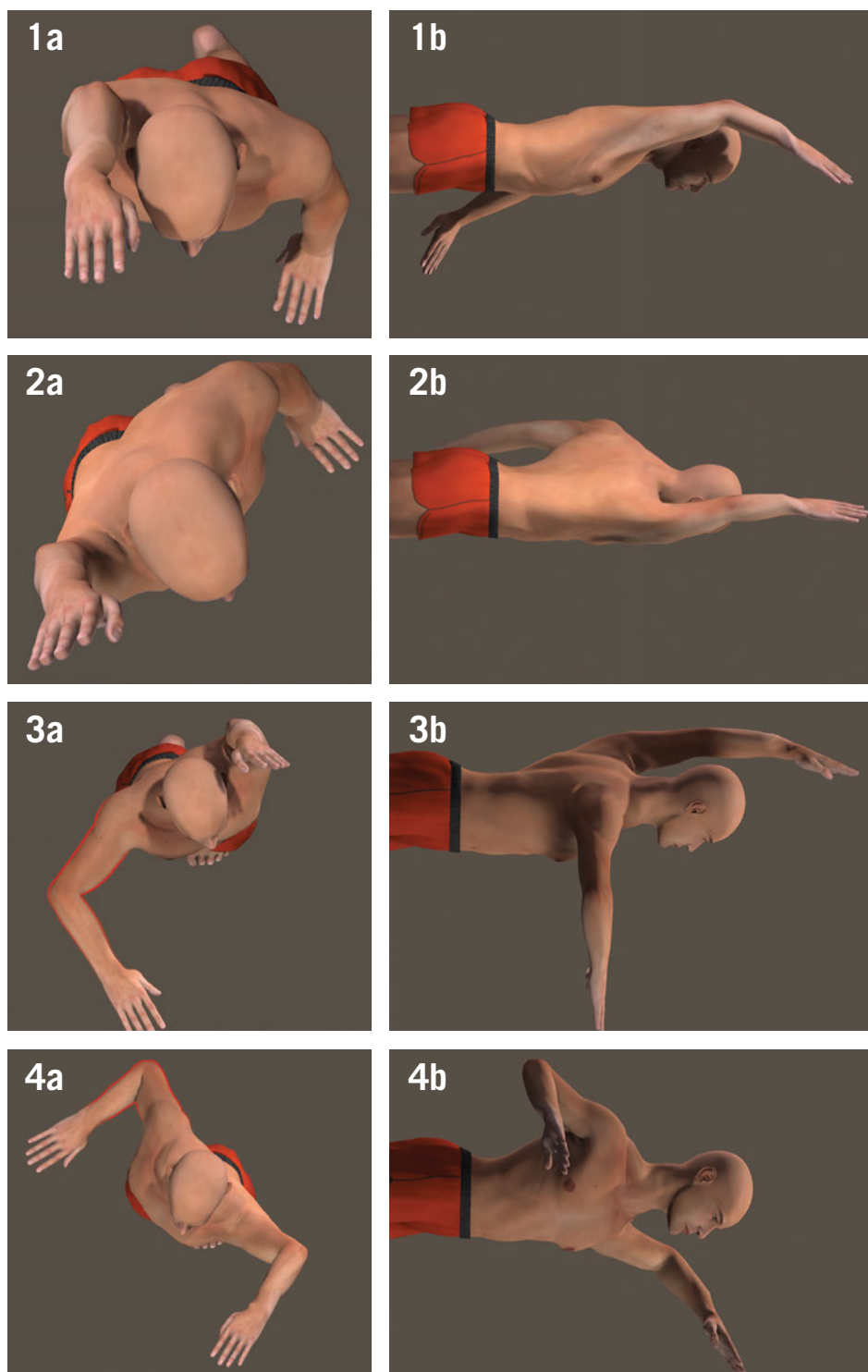


Figure 1: Hand entry.

Figure 2: The reach.

Figure 3: The pull-through phase.

Figure 4: The recovery phase.

1. the hand entry,
2. the reach/glide,
3. the early pull-through,
4. the late pull-through and
5. the recovery phase.

For the purposes of this paper we will collapse these stages to increase their clinical relevance, but be careful using our terms with coaches who will be more familiar with the biomechanical definitions above.

The hand entry is right in front of or slightly medial to the shoulder, close to 75% of the total arm length. The elbow is at a small flexion angle, allowing the fingers to make the first contact with the water.

When the wrist and elbow touch the water, the hand is reaching forward and gliding until full elbow extension – the reach. After this, the hand ‘catches’ the water in about 40° of wrist flexion. The shoulder is now in full flexion, abduction and internal rotation.

Following the catch phase is the early pull-through phase, up to the moment the arm reaches a position at the same level of the shoulder with the elbow in 90° flexion. The hand seems to either take an S-shaped path (at slower speeds) or a straighter path at higher speeds, but should not cross the midline of the body.

The late pull-through follows with a forceful extension and the stroke should finish with the hand past the hip. There is an accelerated thrust at the end of the pull-through phase with palmar flexion and internal arm rotation to the surface for the exit.

The shoulder lifts out of the water for the recovery phase. Shoulder abduction and internal rotation is followed by external rotation. The elbow will be high (if possible) and the wrist in front of the elbow as soon as possible. With a relaxed forearm, the arm then moves forwards over the water to begin a new stroke with hand entry.

BODY ROLL

The shoulders and torso are rotating around the midline body axis during the entire arm stroke – the ‘body roll’. Body roll is important for maximum thrust as it brings the shoulder closer to a midrange position during propulsion and simultaneously allows the recovering arm to more easily exit the water without exaggerated horizontal abduction.

Swimmers roll both their shoulders and hips, however the shoulder roll is significantly more than the hip roll, accordingly the trunk is undergoing relative rotation. The amount of trunk rotation however varies between swimmers and seems to be less at higher swim speeds. A swimmer with a reduced active or passive trunk rotation range of motion (ROM) will find this difficult or impossible to achieve and thus thoracic rotation range becomes a key assessment finding and potential treatment aim.

Yanai and Hay⁷ investigated the often repeated claim that increasing body roll would result in the supraspinatus tendon being placed in an 'at risk' position for a shorter duration of the stroke cycle and accordingly would be a possible factor in reducing shoulder injury incidence. This validation study on 11 healthy university-

level swimmers did not support this contention showing poor correlation between the amount of body roll and percent of the stroke cycle that the shoulder was in an 'impingement position'. Conversely, the same authors showed a higher correlation between the amount of trunk side flexion and percent of time in an at risk position. These preliminary results suggest an interplay between the individual anatomic features of the swimming technique and the load placed on the shoulder during any stroke. For this healthy cohort, the shoulder was seen to be in an 'at risk' position for the longest duration during the recovery phase, next most frequently during the catch phase and almost always the shortest duration of risky positioning was during the propulsive phase. It is noted, however, that great variability was seen both between and within individual swimmers.

A CLINICAL APPROACH TO A SWIMMER WITH A SHOULDER INJURY

History

A very thorough sport-specific history is important. As most shoulder injuries in swimmers are overload injuries, the history directs the clinician to the most likely diagnoses and contributing factors. If the swimmer doesn't tell you, ask **when** during the arm stroke they experience their pain; ask the swimmer to mimic that in the room. Typically, the pain is initially only felt during the provoking phase (catch, propulsion or recovery) towards the end of a training session. Certain weight training or land exercises may also be painful.

Then ask **where** – commonly swimmers report pain anteriorly, less commonly antero-laterally and occasionally in the posterior rim of the acromion. Try to marry up these reports with your evolving working

CLINICAL TIP

A classic error in the management of shoulder pain is to adjust the training load to less freestyle and arm drills and more endurance-type leg drills using a kick board. The arms are overstretched on the kick board in maximum shoulder flexion, which may even aggravate impingement symptoms. It is initially counter-intuitive, but the use of pull buoys (floats between the legs) can reduce shoulder load as long as the stroke rate can be significantly slowed, with attention to correcting technique without the risk of the legs sinking and greatly increasing drag. This can be a useful strategy to both unload the shoulder and begin technique correction where indicated.



Figure 5: Clinical tip.

diagnosis, considering the phase of the stroke and arm position they reported to you earlier.

When – a gradual onset is more typical than a sudden onset. Swimmers will often tolerate pain long before presenting to you and may relate earlier ‘odd’ feelings in the same areas that later became painful. This history is important in your classification of the injury (e.g. between an acute proliferative versus a degenerate tendinopathy). Find out, if possible, the relationship between the onset of pain and extrinsic factors such as changing training loads (volume and/or intensity) either in pool or land training. These workload changes are by far the most common causes of the onset of pain. Ask specific questions about the swimming training; how much of the session is warm-up, what sets are used, common drills and warm down. Information about stroke specialty and percentage of training hours swum in this stroke and in freestyle may also be helpful to gain a good understanding of the total shoulder load. Open water swimmers use a slightly different technique than long course swimmers, due to the race distance, buoyancy (use of wetsuits) visibility in the water (no lanes to follow and waves to deal with) and because they are often swimming in a group.

Ask about the total training load, including all the different types of training sessions: swim sessions, land and weight training sessions and alternative cardiovascular training sessions (cycling/running).

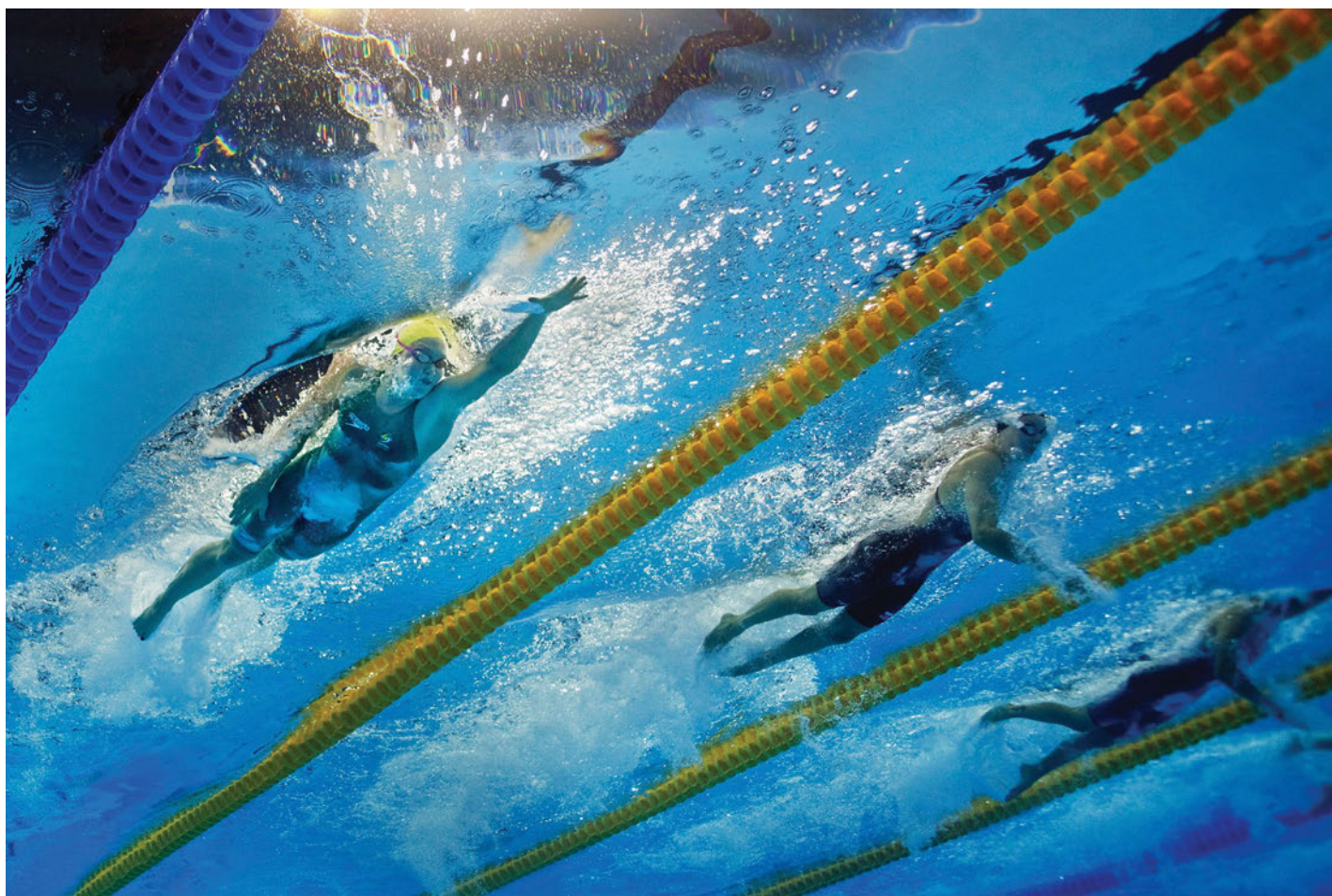
What – The nature of the pain (e.g. sharp, well localised, versus dull aching, spreading, versus ‘electrical’) can also give clues and may suggest focal reactive pathology versus emerging sensitisation and central pain production versus neurological contributors, for example.

General questions are, of course, also important and may include: possible trauma, any other recent or past musculoskeletal issues, (changes in) daily activities, previous investigations and treatments. Many swimmers may have hurt their shoulder playing other sports, so past sporting injury history is also important as well as asking about personal or family history of generalised joint laxity (hypermobility).

Adolescent swimmers are a special group of athletes. Ask about recent growth spurts and don’t forget that the moody hormonal teenager can have other contributing factors to the physical pain of their injury which are unlikely to be addressed by anyone else working with them if you don’t.

There is a higher risk for shoulder injuries:

- After a sudden increase of training volume or intensity¹⁰.
- With a mileage of >35 km/week or > 15 hours swum/week⁹.
- In case of a unilateral breathing pattern⁷.
- After recent change of stroke technique. Ask about any technical flaws that have been pointed out by the coach¹¹.
- With a history of shoulder injuries⁵.



- With a recent change in coach (and therefore likely changed training loads).
- After increased use of hand paddles^{12,13}.
- With the use of drag increasing training devices (bags, elastic cords, dragsuits etc.).

Clinical and functional assessment

Integrate observation and functional assessment

- **Muscle atrophy:** in the case of a long-standing problem, pay careful attention to any observation of unilateral muscle wasting. This can sometimes be seen in the supraspinatus fossa or infraspinatus fossa in the case of recalcitrant tendinopathy.
- **Posture:** watching a high level swim meet, you will quickly be aware of the 'swimmer's posture' of genu recurvatum, increased lumbar lordosis, thoracic kyphosis and protracted, depressed scapulae ('rounded shoulders'). In some individuals this might be due to the generalised hypermobility; Beighton scoring can be useful in assessing whether this is genetic or acquired¹⁴. The high demand of the adductors and internal rotators of the shoulder results in excessive development of the anterior chest and internal rotators. This might ultimately create internal and external rotator muscle imbalance and the appearance of rounded shoulders¹⁵.
- **ROM:** increased ROM has been reported to be advantageous for competitive swimmers; swimmers will present with overall increased ROM in glenohumeral and scapulothoracic articulations. Although in the shoulder, rotational movements provide more reliable and clinically relevant data than other movements, significant differences are found when comparing the evidence. A total rotational range of motion (TRROM, the sum of internal and external rotation) of between 130° and 165° has been reported in swimmers. The individual values for internal and external rotation are however highly variable¹⁶⁻¹⁸. External rotation of more than 100° or less than 93° degrees has been associated with shoulder impingement⁵. In the absence of injury the TRROM should be the same for both arms of any particular swimmer. Variations in the amount of twist about

the long axis of the humerus (humeral torsion) both within and between swimmers have been documented and are important to consider clinically when there is a side-to-side difference in TRROM. This variation in humeral torsion effectively shifts the TRROM such that greater retrotorsion will result in an apparent increase in external rotation with a concomitant reduction in internal rotation of the same amount. As such, the healthy shoulder's TRROM, along with the side-to-side difference in torsion can be used to predict rotational range of motion targets for an injured shoulder. Simply considering one end of the rotational range (typically lost internal rotation or 'glenohumeral internal rotation deficit') can lead to erroneous assessment findings and misplaced treatment goals when the TRROM and differences in torsion are ignored.

- **Scapulothoracic articulation:** although being of importance in swimmers, measurement of scapular motion is problematic as our measures currently don't correlate well with the presence of pathology. Nonetheless, clinicians should attempt to document potential movement limitations, mainly due to stiffness in the surrounding tissues or motor control dysfunctions¹⁹ and attempt to link these to the other clinical findings. Insufficient scapular upward rotation during the arm stroke could be a result of tightness of the short scapulohumeral muscles or simply incorrect motor patterns. Rotator cuff overload is more likely with this insufficiency. The position of the scapula at rest can already give some information about muscle tightness. Observing scapular movement, especially in the reported painful positions, can shed light on the involvement of scapular dyskinesis in the presenting problem. Due to the high false positive rate of scapular dyskinesis, it's recommended that the examining clinician find a positive link between changing the scapular position and altering the swimmer's pain before declaring the dyskinesis and the presenting pathology related. In a study of 78 pain-free swimmers, scapular dyskinesis became increasingly more frequent during a training session. This suggests that scapular dyskinesis may be partly fatigue related²⁰.



It is likely that overload, especially an abrupt increase in relative training load, is important in developing injury



- **Cervical and thoracic spine range of motion:** clinically it is worthwhile assessing the ROM of the cervical and thoracic spine, particularly toward side flexion and extension (as they can contribute to placing the shoulder in a good position at the catch – see Figure 7). Similarly, trunk and cervical rotation are important as described earlier in relation to body roll.
- **Strength changes:** previous research using isokinetic dynamometry examined for rotational and frontal plane strength changes, however it is rare to have this assessment available in the clinic. Hand-held dynamometry could represent a more practical and time-efficient method to accurately quantify side-to-side differences in strength as well compare strengths with expected norms. Unpublished research suggests that the internal rotation strength (measured by the side) will be equal to 20 to 30% of the athlete's bodyweight and the internal to external rotation strength ratio is <1.5 in healthy athletes. In healthy swimmers you will typically see greater internal rotation strength than in non-swimmers, likely related to their history of swimming training.
- **Palpation:** palpation of the acromioclavicular joint, rotator cuff tendons and bicipital groove are helpful to assess the structures involved. As firm palpation of these structures can often be uncomfortable, it's recommended to palpate bilaterally and ask the swimmer if one side feels different to the other, rather than 'does this hurt?' to avoid false positives.
- **Special tests:** rotator cuff tendons are often affected and assessment of these muscles should be included. Pain provocation tests are used to assess the possible involvement of other shoulder structures including the AC joint, labrum, joint capsule and muscles/tendons.
- **Laxity:** the role of generalised joint laxity (hypermobility) in the risk of shoulder injury remains controversial. Swimmers might be 'preselected athletes' with increased shoulder joint laxity being considered as 'normal' for



them. Past research, however, found only 20% of the swimmers meet the criteria for hypermobility¹⁶. A Beighton hypermobility score may help the clinician to assess the presence of generalised laxity¹⁴.

- **Core function:** there is a lot of debate about the role of core function in injury risk as well as measuring core stability. While we lack any validated tests of core function; the bridge, side bridge, Superman and single leg squat are some of the screening tests used by clinicians to assess core function. We suggest that the front plank and Superman are likely the positions giving the most information about the athlete's ability to efficiently transfer load between the arms and the legs under internally generated flexion torques. Such assessment is likely useful as this ability is important for:

- keeping the swimming body in a streamlined position, minimising the drag.

- reducing the shoulder load by optimising body position for propulsion.

Investigations to consider

The most important role of diagnostic imaging studies is to rule out other more significant pathologies, including bone and soft tissue tumours.

X-rays are important to exclude calcifications in the supraspinatus tendon or in the subacromial bursa. It will show the morphology of the acromion and rule out another pathology due to previous injury.

Ultrasound (US) is both cost effective and dynamic. However, it is very operator- and hardware-dependent. In skilled hands it is extremely useful for detecting partial thickness rotator cuff tears, degenerative tendinosis with or without increased Doppler blood flow and bursitis. The diagnostic accuracy is, with an experienced radiologist, at the same level as that of an MRI scan and has the advantage of being able to be correlated with clinical



Figure 6: Swimming shoulder injury treatment process. ROM=range of motion, TRROM=total rotational range of motion, AC=acromioclavicular, PB=personal best, MRA=magnetic resonance arthrography, NSAID=non-steroidal anti-inflammatory drug.

findings and subjective reports during the examination.

MRI is more expensive and could show partial rotator cuff tears, bursitis and tendinopathy. MR arthrography might be the most precise diagnostic tool but care should be taken as many swimmers might have asymptomatic anterior labrum abnormalities.

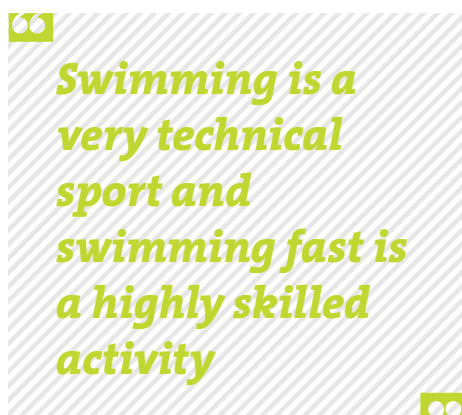
The key message remains: treat the patient and not the scan and use imaging to confirm a clinical diagnosis or exclude more serious pathology!

Is it always possible to make a pathoanatomical diagnosis?

Is it scapular dysfunction, anterior instability or tendinopathy? Or a combination?

Sein⁹ concluded that rotator cuff tendinopathy is the most common pathology in shoulder injuries in swimmers and we would concur with this conjecture.

Although an accurate anatomical-pathological diagnosis might be important, it will often be elusive. What remains critical though is to diagnose and understand the underlying functional or patho-mechanical reasons for the 'structural failure' and address these in the management plan.



Management plan

Early consultation by a sports medicine clinician, or better, a team including physician, physiotherapist and strength and conditioning coach is important. Longstanding complaints aggravate dysfunction and pathological findings of the kinetic chain, with secondary pathologies and maladaptive compensatory movement patterns making treatment more difficult. The management plan depends on the functional and pathoanatomical diagnoses, taking into account the severity and duration of the shoulder injury as well as the expectations of the athlete.

In swimming, the three scenarios (outlined below) would cover a large proportion of shoulder pain in practice. Stiffness and weakness of the glenohumeral and scapulothoracic structures are perhaps the primary deficits to consider and might vary according to the mechanism and onset of pain. Individualised rehabilitation programmes emphasising range of motion, flexibility, muscle balance and motor control of the glenohumeral and scapulothoracic joints are the key features in the management of shoulder pain in swimmers²¹. Optimal stretching and core stability exercises would facilitate a complete management²².

Treatment for shoulder injuries consists of:

- Active rest and modification of training load and intensity, combined with ice application after training sessions.
- Short term anti-inflammatory or analgesic medication might be considered for inflammatory conditions like bursitis or pain relief during competition. The hallmark of management, however, is load adjustment and functional correction, not medication or injections!
- A team approach: technical stroke analysis and adjustment with the coach, physiotherapist and sports medicine physician keeping the findings during the consultation in mind.
- Avoid long leg drills with a kick board, hand paddles and pull buoys.

- Individualised exercise programme with the physiotherapist and strength and conditioning coach to optimise dysfunctions.

Daily pain is indicative of a more longstanding and severe shoulder injury. The pain is not only felt during specific exercises or phase of the arm stroke, but constant and may affect activities of daily living.

Re-assess the athlete on a regular basis. Consider surgical referral very carefully and perhaps only if there is no improvement of the symptoms after (active) rest and exercise therapy for a minimum of 3 months (unless there is an obvious and more urgent reason for surgical intervention).

Once a swimmer has returned to healthy training, an ongoing management strategy addressing the previous predisposing factors (intrinsic and extrinsic) is important to reduce the likelihood of recurrence. The athlete (and coach) should be instructed on early identification and remediation of these factors as they become problematic. For example, if a specific reduced flexibility was implicated in the pathology, then a regular practical assessment of this range of motion should be implemented in the swimmer's ongoing programme with suggestions for early intervention as these measures change.

CONCLUSION

In conclusion, shoulder injuries can be managed successfully in swimmers by using an integrated, multidisciplinary approach. It is essential to consider and manage all potential intrinsic and extrinsic contributing factors, particularly training load and swimming technique flaws. Early recognition and intervention is the key to success!

See below for case presentations:

Case 1 – 'My shoulder is painful during the hand entry and catch phases of freestyle'

Case 2 – 'My shoulder is painful during pull through phase of freestyle'

Case 3 – 'My shoulder is painful during the recovery phase of freestyle'

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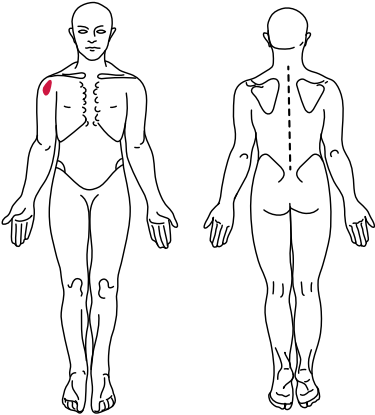

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CASE 1 – ‘MY SHOULDER IS PAINFUL DURING THE HAND ENTRY AND CATCH PHASES OF FREESTYLE’

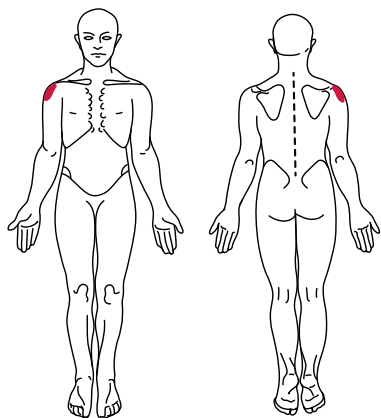
Key clinical findings		Clinical reasoning
 <p>Sharp localized anterior shoulder pain, visual analogue scale: 6/10</p>		
When?	During the hand entry and catch phases of freestyle	Shoulder is in forward flexed position. Increased loading of the long head of the biceps and supraspinatus tendons, and subacromial bursa
How long?	On and off for 3 months, much worse over the last week	Likely not acute inflammatory in nature as primary pathology
Technique related?		Much more likely that shoulder is in a position to compromise the subacromial contents, similar to the position of the Neer impingement sign
	Hand entry and glide too adducted, potentially excessive forward flexion by striving for a long stroke Scapula elevation and thoracic spine side flexion?	Crossing the midline or too abducted could also increase loading
Related factors	Recent increase in training volume preparing for upcoming national championships	
Physical exam	Coachin tip: thumb-first hand entry	More internally rotated and abducted shoulder to achieve this position, stressing the biceps tendon at the anterior labrum
	Scapular dyskinesia: reduced upward rotation, painful at end range flexion. Pain reduced on manually assisting upward rotation of the scapula	Definitely need to address scapular positioning during the glide and catch phases, increase upward rotation

	<i>Reduced ROM of cervical and thoracic spine extension, rotation, and side flexion</i>	<i>Likely stiffness in these areas contributing to incorrect positioning of the arm at reach/catch</i>
	<i>Rotational ROM: reduced right shoulder internal rotation range with painful end of range</i>	<i>Don't address this ROM reduction until painless internal rotation passively is possible for fear of aggravating condition</i>
	<i>Antalgic reduction of both internal and external rotation strength</i>	<i>Need to reassess when painless to determine if this is antalgic (strength will be restored) or genuine muscle wasting (strength will remain reduced)</i>
	<i>Positive Neer impingement sign (pain)</i>	
	<i>Beighton: 6/9</i>	<i>Probably need to adjust expectations for range of motion a little higher in the shoulder. Ongoing strengthening program more important once symptoms resolve</i>
<i>Investigations</i>	<i>Ultrasound of shoulder shows subacromial bursal bunching, some minor degenerate changes in the supraspinatus tendon, but some changes also on the unaffected side</i>	<i>In the clinical context, likely the symptoms are arising from the tendon and/or bursa, however some changes are loading related and common in all swimmers</i>
<i>Management plan</i>	<ul style="list-style-type: none"> <i>- Temporary unloading via modification of training to reduce time spent in 'at risk' position</i> <i>- Consider short-term anti-inflammatory use</i> <i>- Scapular upward rotation during retraining of overhead exercises</i> <i>- Short term reduce stroke length</i> <i>- Reduce distance drills (where long stroking is encouraged)</i> <i>- Pull-buoy drills to retrain technique – slow stroking emphasised</i> <i>- No kick drills with kick-board in front or drag suits. Kicking drills on side, or with board under chest (not full flexion of the shoulder)</i> 	
<i>Reassess</i>	<i>Review in 2 weeks</i>	<i>If not settling, need to consider possibility of addressing lost ranges of motion at the shoulder earlier, re-assessment of other structures.</i>

CASE 2 – ‘MY SHOULDER IS PAINFUL DURING PULL THROUGH PHASE OF FREESTYLE’

Key clinical findings

Clinical reasoning



Dull regional anterolateral pain, visual analogue scale: 3 to 4/10

When?

During the pull through phases of freestyle

Shoulder is moving from forward flexed position to extension. From abduction to adduction and internal rotation

How long?

Since the start of the season, 8 months ago

Likely an overload injury, reason?

Technique related?



Hand crosses the midline axis and lack of body roll. Dropped elbow (elbow below the level of the hand - side view)

Straight pull through or S-shaped? velocity dependent? Exaggerated body roll?

More prominent S-shaped pull through, lack of body roll and/or hand crosses the midline: increase loading of the subacromial structures

A dropped elbow increases external rotation in the glenohumeral joint: propulsive muscles could be placed at a mechanical disadvantage. Propulsive force is less, due to a smaller area of thrust

An exaggerated body roll gives more horizontal abduction, potentially stressing the anterior shoulder structures

Related factors?

Recent change in club and coach: at the beginning of this season

Other training drills: more pace work, frequent use of drag suits and elastics

Sport history: tennis for 5 years, stopped 2 years ago because of a right shoulder injury

*Muscle wasting right supraspinatus fossa
Right shoulder sitting more anteriorly in supine relaxed position than left*

Increased intensity and more power needed, putting the shoulder more at risk

It could be a longstanding problem, triggered by the recent change in training

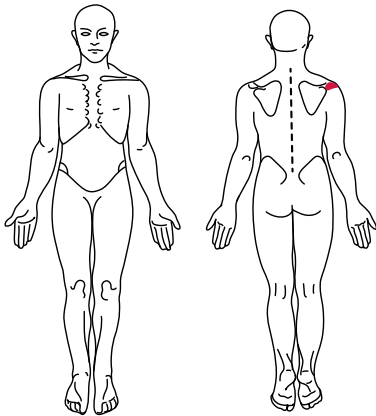
Physical exam

*We're facing a longstanding problem
Could be pectoralis major shortening or overactivity*

	Scapulothoracic dyskinesis. Reduced ROM of cervicothoracic junction (spine)	Longstanding problems could cause motor dysfunction with stiffness of the surrounding tissues. Assess scapula movement when applying force in the pull through position
	Rotational ROM: reduced right shoulder internal rotation, painless stiff end feel	Sleepers stretch exercises could be useful
	Internal rotators much stronger than external rotators.	This may promote dynamic imbalance with increased loading of joint structures
	Positive Hawkins and Kennedy test	Impingement test: mimics joint position at mid pull through (see image above)
	Palpation of the supraspinatus tendon is painful	Possible anatomic source of the pain
Investigations	MRI of shoulder shows degenerative changes and partial tear of the right supraspinatus tendon, the subacromial bursa shows some fluid	
Management plan	<ul style="list-style-type: none"> - Temporary unloading via modification of training to reduce time spent in 'at risk' position - Cessation of drag suits and elastics - Scapular muscle retraining throughout shoulder range - Manual therapy for the cervicothoracic junction - Work on pectoralis major length/tone as indicated - Graded supraspinatus exercises - Pull-buoy drills to retrain technique – slow stroking emphasized - Adjust swimming technique: don't cross midline, scapula positioning 	
Reassess	Review in 6 weeks	Reassess all the clinical findings, adjust therapy as needed, adjust swimming technique

CASE 3 – ‘MY SHOULDER IS PAINFUL DURING THE RECOVERY PHASE OF FREESTYLE’

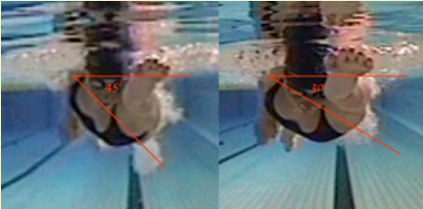
Key clinical findings		Clinical Reasoning
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Posterior shoulder pain visual analogue scale: 7 out of 10

When?	During the recovery phase of freestyle	Shoulder abduction and internal rotation is followed by external rotation. The elbow will be high (if possible), the forearm relaxed and the wrist in front of the elbow as soon as possible.
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How long?	2 years an odd feeling during intense training periods, worsened especially over the last 2 weeks	Acute on chronic?
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Technique related?	 <p>A lack of body roll. ? High elbow during recovery</p>	The body roll should be around 45 degrees for the recovery phase. An excessive body roll can lead to crossover hand entry or passing the midline axis during pull through of the opposite arm. A lack of body roll can increase the mechanical stress on the shoulder and lead to improper hand entry position.
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		When the elbow is lower than the wrist during the recovery phase, the elbow can enter the water before the hand resulting in an extremely inefficient early propulsive phase.
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Related factors?	Started with an intense training period 2 weeks ago.	
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	Just switched from unilateral breathing pattern to bilateral breathing pattern	A unilateral breathing pattern can cause asymmetric stroke, asymmetric body roll, which can place the shoulder more at risk
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	Marfan's Syndrome	Generalised joint laxity
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Physical exam	Swimmer's posture	Genu recurvatum, increased lumbar lordosis and thoracic kyphosis, rounded shoulders
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	<i>Left thoracic rotation less than right. Preference breathing side: right.</i>	<i>Cause for unilateral breathing pattern in the past?</i>
	<i>Rotational range of motion: bilateral external rotation 110</i>	<i>External rotation >100 degrees is associated with more loading of the subacromial structures</i>
	<i>Internal rotators obviously stronger than external rotators:</i>	<i>dynamic imbalance.</i>
	<i>Beighton score 9/9</i>	<i>Generalised joint hypermobility, due to Marfan syndrome</i>
	<i>Core-stability assessment: Superman and bridge good, but pelvis shift in plank position. Single leg squat: Trendelenburg and corkscrew</i>	<i>Superman, bridge and plank are common exercises during land training for swimmers. Single leg squat is not often used and should be reassessed after correction and explanation</i>
<i>Investigations</i>	<i>X-rays shows Hill-Sachs lesion</i>	<i>After this finding, the swimmer reports he has had a shoulder dislocation 10 years ago</i>
<i>Management plan</i>	<ul style="list-style-type: none"> - Temporary unloading via modification of training to reduce time spent in 'at risk' position - Cessation of drag suits and elastics - Scapular setting optimisation - Manual therapy for the thoracic rotation - Work on rotator cuff strength - Adjust swimming technique: start bilateral breathing pattern when thoracic rotation has improved 	
<i>Reassess</i>	<i>Review regularly (weekly)</i>	<i>After 6 weeks the improvement flattens out, pain persists</i>
<i>Subsequent investigations</i>	<i>MRA shows irregularity of the anterior and posterior labrum, without tear and supraspinatus tendinopathy</i> <ul style="list-style-type: none"> - Temporary cessation of swimming practice - Consider anti inflammatory drugs - Intense rehabilitation 	
<i>Management plan</i>	<ul style="list-style-type: none"> - Reassess swimming technique with coach and adjust to optimal body roll, adjust breathing pattern as needed - Personalised exercise program to optimize strength and minimise risk for muscular imbalance - Refer to cardiologist for assessment if not done so in the past, because of a higher risk for cardiac disease in Marfan's Syndrome. 	