FACTORS PREDISPOSING TO SHOULDER INJURIES IN ELITE SWIMMERS

A LITERATURE REVIEW

■ *J A Hall, MSc (Physio) Wits*
J Milligan, BSc (Physio) Wits, BSc Hons (Sports Medicine) UCT
A Stewart, BSc (Physio), DPE, MSc (Medicine) Wits

INTRODUCTION

Swimming is a popular recreational and competitive sport in many countries, including South Africa.

Competitive swimmers in training are likely to swim between 12 000 metres per day (sprinters) to 18 000 – 20 000 metres per day (distance swimmers)[16]. As these distances are covered daily for ten to eleven months of the year, five to seven days per week, swimmers are susceptible to microtraumatic overuse injuries of the shoulder[6]. Acute, macrotraumatic injuries may also occur.

This review aims to describe normal stroke mechanics, shoulder injuries common to swimmers and also to identify risk factors predisposing to injuries of the shoulder in the child and adolescent elite swimmer. This becomes particularly important when it is realised that elite swimmers begin swimming competitively by the age of eight and are thus at risk of injuries to the cartilage of epiphyseal plates, joint surfaces and apophysial insertions of tendons.

NORMAL ARM ACTION

TABLE I: NORMAL ARM ACTION

PHASE	STAGE	SHOULDER ACTION	BODY ACTION
FREESTYLE			
Pull-through	Hand entry	Abd & ext rotation	Roll begins
	Mid pull-through	90° abd, neutral rotation	Roll at maximum
	End of pull-through	Add & internal rotation	Neutral
Recovery	Elbow lift	Abd and external rotation	Roll in opposite direction
	Mid recovery	90° abd & ext rotation	Maximum roll
	Hand entry	Abd & external rotation	Neutrol
BACKSTROKE			
Pull-through	Hand entry	Abd & ext rotation	Roll begins
	Mid pull-through	90° abd, neutral rotation	Maximum roll
	End of pull-through	Add & internal rotation	Neutral
Recovery	Hand lift	Abd & ext rotation	Roll
	Mid recovery	90° abduction	Maximum roll
	Hand entry	Maximum abduction	neutral
BUTTERFLY			
Pull-through		As for freestyle hands spread apart at mid pull-through	No roll ·
Recovery		As for freestyle	No roll – body lifts to allow arms to clear water

Table I describes the normal arm action in freestyle, backstroke and butterfly. Breaststroke is excluded because the greater part of the propulsion is derived from the leg action[5].

"Dropping" the elbows causes increased external rotation and thus impedes propulsion. This is a clear sign of fatigue in a young swimmer with untrained adductors and internal rotators, because they cannot generate the force required during the recovery phase.

Nuber *et al* (1986)[14] found that supraspinatus, infraspinatus, middle deltoid and serratus anterior were predominantly recovery phase muscles, being active throughout the phase. Serratus Anterior demonstrated a peak activity which occurred at hand entry and early pull- through phase. This highlights the importance of scapula rotation when the arm is fully abducted. Latissimus Dorsi and the clavicular head of pectoralis major were the major pull- through muscles. Latissimus dorsi was most active at 90 degrees of abduction as the shoulder progressed from external rotation to internal rotation. There was a constant low level of activity in the Biceps in both phases. The elbow was flexed during both recovery and pull- through phases which would initiate biceps activity.

COMMON SHOULDER COMPLAINTS IN SWIMMERS

IMPINGEMENT SYNDROME

Richardson *et al* (1980) found that the pain was located about the acromion and always involved the coracoacromial arch in some way[17]. The coracoacromial arch consists of the coracoid process, the coracoacromial ligament and the acromion. The supraspinatus and biceps tendons lie beneath the arch. Impingement generally occurs against the anterior edge of the acromion and the coracoacromial ligament as described by Neer (1972)[13].

The greater tuberosity impinges against the lateral acromion and underneath the acromioclavicular joint with progressive abduction as, for example, occurs in the freestyle stroke.

In addition, Rathbun and MacNab (1970) demonstrated areas of avascularity in the supraspinatus and biceps tendons when held in the dependent position in which position both tendons are used[16]. It is felt that the irritation caused by the mechanical impingement of the avascular region of the supraspinatus leads to a tendinitis, which may progress to secondary involvement of the biceps tendon and rotator cuff tears[5,8]

ANTERIOR GLENOID LABRUM DAMAGE

This lesion may result from anterior subluxation which may damage the labrum. This can occur as a result of the swimmer's arm motions and increased capsular laxity which may cause subclinical anterior subluxation which damages the anterior glenoid labrum. The patient presents with pain and a click on adduction and internal rotation as the lesion produces compression of the articular surfaces[9]

TABLE II: SWIMMER WITH A HISTORY OF SHOULDER PAIN

AUTHORS	COUNTRY	NUMBER OF SWIMMERS	% OF HISTORY WITH SHOULDER PAIN MALE	FEMALE
Kennedy & Hawkins[7] 1974	Canada	2,496 (Competitive)	Not provided	
Richardson, Jobe % Collins[17] 1980	U S A	63 (nonelite)	38	23
		38 (elite)	47	57
		63 (world championship team)	50	68
		TOTAL	46	40
McMaster & Troup[11] 1993	U S A	993 NAG*	55	38
		198 SED**	67	64
		71 National Team (elite)	71	75

* NAG: National Age Group 13–14 years old
** SED: Senior Development 15–16 years old

INCIDENCE

The incidence of shoulder pain in competitive swimmers in North America has been established by surveys.

The study by McMaster and Troup (1993) differentiated between swimmers currently experiencing shoulder pain and those who had suffered from shoulder pain at any time during their swimming careers[11]. Whereas 38% to 75% had a "history of pain at some time", only 9% to 35% experienced "current pain".

The findings of McMaster and Troup[11] and Richardson, Jobe and Collins[17] are in sharp contrast to those of Kennedy *et al*[7]. It is possible that the swimmers surveyed in the cross-Canada analysis, although swimming competitively, were not of the same calibre as those assessed in the United States studies. It is reasonable to expect the percentage of shoulder injuries to be higher in the elite swimmers as the distances swum in training will be greater and the length of time for which they have been training greater.

PREDISPOSING FACTORS

AGE OF ONSET OF SHOULDER PAIN

The average age at commencement of competitive swimming ranges from 7,3 to 8,5 years[11].

Neither the 1980 or the 1993 USA studies specify the age at which the swimmers first presented with shoulder pain. The survey by McMaster and Troup (1993) indicates that 55% of boys and 38% of girls in the NAG group (13–14 years old) already had a history of shoulder pain.

McMaster and Troup[11] stated that the average age of referral for initial complaints of the shoulder is 18 years.

SEX OF SWIMMERS

A greater percentage of men experienced shoulder problems than women[11,17]. The higher incidence of shoulder pain in men may be explained by a number of factors.

Reduced buoyancy, coupled with the more rapid and ballistic arm motions of the male swimmer result in a greater torque applied through the shoulder joint and greater body drag during propulsion through the water. These differences necessitate the generation of a greater pull-through strength (lift) by the male swimmer[10,11].

STROKE RELATIONSHIP

Ninety-two percent of swimmers presenting with shoulder pain swam freestyle, butterfly or backstroke in competition and 90% also identified one of these three strokes as their second best stroke as well[17]. This concurs with the findings of the Cross-Canada survey[7], in which the shoulder complaints were caused primarily by the freestyle and butterfly strokes and occasionally by the backstroke, although an exact breakdown of percentages was unavailable.

Swimmers surveyed in McMaster and Troup's study indicated that the butterfly stroke was the most painful to perform because of the force required to lift the body out of the water[11].

UNILATERAL VS BILATERAL PAIN

The swimmers surveyed by Richardson *et al*[17] ranged in age from 14 to 23 years. The numbers complaining of bilateral pain in McMaster and Troup's[11] study are significantly higher in the NAG and SED groups which have swimmers who have presumably been swimming competitively for only 5-8 years.

TABLE III: UNILATERAL VS BILATERAL PAIN

STUDY	BILATERAL PAIN		
Richardson *et al*[17] 1980	15% (sex unspecified)		
McMaster & Troup[11] 1993		Female	Male
	NAG	30%	60%
	SED	55%	45.5%
	US Team	62%	57%

SIDE OF PAIN

Richardson *et al*[17] demonstrated that 53% of swimmers complained of pain in their right shoulder and 32% suffered from left sided pain.

Ciullo and Stevens (1989) found that 60% of swimmers performing freestyle developed pain on the side on which they breathe, which is the dominant side of 81% of swimmers surveyed[2].

None of the other studies included in this review provided details of the side of pain.

WEIGHT TRAINING

TABLE IV: FACTORS AGGRAVATING SHOULDER PAIN

TRAINING ACTIVITY	SWIMMERS WITH INCREASED SHOULDER PAIN %					
	NAG		SED		ELITE	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
Weights	7	11	21	41	38	29
Paddles	13	21	56	68	91	100
Surgical tubing	0	0	23	32	43	17
Stretching	7	11	21	41	38	29
Kickboards	9	11	38	14	67	14

Weight training has become an integral part of preparation for competition, but may contribute to shoulder pain[12]. The pattern of movement used in weight training was not described. Some swimmers felt that the use of weights decreased shoulder pain. This is in contrast to the findings of McMaster and Troup[11], where the respondents to their survey indicated that weight training increased the pain (Table IV).

Brady *et al* cautioned that weight training needs to be closely monitored and designed for the needs of the swimmer[1]. The patterns of movement during weight training need to be carefully taught. Caution needs to be exercised in the commencement of weight training in pre-adolescent swimmers. A number of swimmers begin weight training before the age of 10 which may be a cause of growth plate injuries[12].

RESISTANCE TRAINING

Resistance training is necessary to improve power and strength after stroke techniques have been perfected.

Hand paddles are a popular method of resistance training. The use of the hand paddle increases the load on muscles of the upper extremity and increases the length of time spent in the pull-through phase[18]. This phase, together with the recovery phase, produced pain in 75% of the swimmers surveyed by Richardson[17]. The remaining 25% experienced pain in either the pull-through or recovery phase alone.

Of the groups surveyed by McMaster and Troup[11] the use of hand paddles ranged from 70% of the female SED group to 91% of the elite male swimmers and was seen to aggravate shoulder pain. The percentage of swimmers in which this occurred is seen in Table IV. In Richardson's study, 81% of the swimmers found that the use of hand paddles aggravated their pain[17]. Resistance training using surgical tubing appears to be less widely used, but again is reported to exacerbate shoulder pain[15] (Table IV).

FLEXIBILITY

Greipp (1985) studied shoulder flexibility in a group of 168 swimmers before the start of the swimming season in order to predict the incidence of shoulder pain. Results indicated that the poorer the shoulder flexibility the higher the incidence of shoulder pain[4]. He suggested that posterior shoulder looseness could be associated with his findings. The postural forward shoulder slump often seen in swimmers tends to support this[4].

MUSCLE STRENGTH

The stroke mechanism emphasises internal rotation and adduction of the shoulder and it is not surprising that swimmers show significantly greater torque values of these movements.

Warner *et al* (1990) indicated an increase in the internal/external rotation ratios in patients suffering from impingement syndrome, due to an increased internal rotation strength[18].

It is the rotator cuff muscles which provide dynamic humeral stability and prevent vertical displacement of the humeral head during elevation.

A significant muscle imbalance may therefore result in upward displacement of the humeral head resulting in impingement.

KICKBOARDS

The flexion and adduction of the shoulder which is required to hold the board may cause symptoms of impingement. (Table IV)[17].

EVENT

The findings of Richardson *et al* indicate that shoulder pain is more common in sprinters and middle distance swimmers[17]. Long distance swimmers swim further during practice[18], but the more forceful arm movements of the sprinter may cause impingement of the supraspinatus tendon in the subacromial space[2].

CONCLUSION

South Africa's re-entrance to international sport competitions is likely to cause an increase in young participants with their sights set on the 1996 or 2000 Olympic Games.

Similar surveys to those performed by McMaster and Troup and Richardson *et al* would need to be carried out in South Africa to determine which of the risk factors detailed in the review are problematic in South African swimmers. The coaches, parents and swimmers would then need to be educated in order to increase their awareness regarding the prevention, early identification and successful management of injuries that may occur.

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