Spinal Musculoskeletal Injuries Associated with Swimming: A Discussion of Technique

Henry Pollard BSc, GradDipChiro, GradDipAppSc, MSportSc, PhD. *
Matt Fernandez BSportSc, MChiro. †

Abstract

Objectives:

To review the biomechanics of the swimming stroke and examine common injuries which occur in swimming. A review of diagnosis and management strategies of these injuries is also performed.

Background:

Most injuries and complaints encountered in swimming athletes occur because of repetitive microtrauma or overuse, with many injuries originating from faulty technique and poor swimming biomechanics. As a result, assessment of an injured athlete requires the practitioner to have an understanding of the four swimming strokes and hydrodynamics.

Methods:

A Literature search of the MEDLINE and MANTIS databases was performed on all swimming related articles.

Results:

Twenty seven journal articles and 7 text books were chosen that satisfied the search criteria and related to the aims of this review.

Discussion:

The correct swimming technique is discussed and predisposing factors to injury in the stroke are identified. Specific injury sites are examined and pathologies to these areas are detailed.

Conclusion:

The shoulder, neck and back are the injuries considered in this review. These regions are considered in the total training program of the athlete to identify other factors, such as weight training or other dry land programs that may be contributing to injury. However, whilst rest or reduced training may be necessary for recovery, every effort must be made to keep the swimmer "in the water" as cessation of training may lead to a rapid detraining effect and loss of competitive advantage.

Keywords

Swimming, analysis and movement, wounds and injuries, review literature, chiropractic

Introduction

Swimming is an organized, fast growing sport with competitive swimmers found in abundance in all age groups. Included are those athletes who compete in formal events such as age group, open and masters swimming programs and those who participate in events such as long distance channel swimming, triathlons, surf life saving, general recreation, fitness and rehabilitation. As a result of the widespread participation, the need to investigate injury in these groups is evident. In our search of the literature, injuries to swimmers other than those of elite standard revealed few articles, but did suggest that non elite swimming injuries closely mirror those found in elite swimmers[1].

Swimming is unique in that it provides upper and lower body strength and cardiovascular training, which is performed in a non-weight bearing environment. However the highly repetitive motion of swimming may predispose overuse injury[2-5]. To fully understand the mechanisms leading a swimmer to injury, a thorough knowledge of anatomy and stroke mechanics is essential[2]. Additionally, knowledge on the types of drag (water resistance) and its affect on swimmers are important and will be discussed. Swimmers are subjected to the repetitive strain of many tissues of the spine and upper limb and as a result require positioning themselves in unusual anatomical positions to maximize force production. Poor flexibility of swimming stroke hampers the adaptation of such positions and may predispose to injury. Knowledge of the

* Senior Lecturer:
Dept. Health & Chiropractic
Macquarie University 2109

Correspondence & Private Practice:
PO Box 448
Cronulla, New South Wales 2230. AUSTRALIA
Email: hpollard@optushome.com.au

† Private Practice:
Email: mattfernandez1@hotmail.com

intricacies of the stroke mechanics, the demands placed on the muscular system and how they can impact on normal joint functioning can help the practitioner form an accurate diagnosis of injury. By utilizing knowledge of biomechanics, the practitioner can appropriately select and implement effective treatment and management strategies to address common and uncommon pain presentations.

Methods

A broad based search of the English literature was conducted by utilising the Cumberland College of Health Science's PEDRO database. Medline (1960 - 2001), Mantis (Health Index) (1900 - 2001) using key words: swimming, analysis and movement, wounds and injuries, review, biomechanics, therapy. A manual search was also conducted of journals and textbooks relating to swimming and musculoskeletal therapies in the libraries of Macquarie University (Ryde NSW), Sydney University (Lidcombe NSW), University of New South Wales (Kensington NSW), covering materials of swimming, applied physiology, biomechanics, spinal stability, chiropractic, osteopathy, physiotherapy and manual medicine.

Results

All reference materials were selected based on their relevance to the key words. Twenty-seven journal papers and seven textbooks contained information that related directly to swimming based spinal injury, swimming technique and manual therapy. All resultant papers satisfied the search criteria and related directly to the aims of this discussion.

Discussion

Swimming Biomechanics

Strokes and Hydrodynamics

The biomechanics of each swimming stroke are similar except for breaststroke, which is unique in both the upper and lower extremity motion. The remaining strokes consist of freestyle, butterfly and backstroke. These strokes can be divided into two main phases, the pull (or propulsive) and recovery phases. The pull phase provides movement with the use of two large muscles, the pectoralis major and latissimus dorsi. These act to move the arm through adduction and internal rotation starting from a stretched position of abduction/external rotation. The recovery phase allows the return of the arm to the stretched starting position while the opposite arm completes its pull phase. Efficient recovery is based on the participation of the external rotators and body roll[6].

To appreciate swimming mechanics, a basic understanding of hydrodynamics and related biomechanical issues is needed. Drag is the term commonly used when referring to water resistance[7]. There are three types of drag relevant to the swimmer: form, wave and friction drag. Form drag is water resistance that is dependent on body positioning. The more horizontal the body is positioned in the water, the less form drag. Wave drag is the turbulence at the water surface created by the moving swimmer. Wave drag can rebound from the sides or the bottom of the pool. Frictional drag originates from the contact of the skin and hair with the water. The controversy surrounding the early use of the swimming bodysuit highlighted the role of the suit in minimising frictional drag and the potential unfair advantage that could be acquired through its use. Whilst initially considered unfair, the suit is now acceptable to use in competition. The drag force is also used for propulsion during the pull pattern and the kick.

The lift component was first described by the Bernoulli principle. This principle in swimming relates to water flowing around the hand during the pull and meets on the back edge of the hand. The water flowing around the back of the hand has a longer distance to travel given the roundness of the thumb and pitch of the hand. This pressure creates a resultant force and is directed toward the low pressure zone and is known as the lift force. The lift force is perpendicular to drag force[7].

The path of the hand in the swim stroke is not linear. As a swimmer's hand moves through the water, energy is given to the water and the water moves. The swimmer essentially pushes off "still water" which allows swimmers to generate more force. One of the main reasons swimmers use the "S" shaped pulling pattern is to continually find still water that is not moving to propel themselves forward[7]. These propulsive movements of the arm can be further divided into outsweep, downsweep, insweep and pull phases (see figure 1). The outsweep is the first movement in the underwater stroke for butterfly and breaststroke swimmers. The downsweep performs the same function for freestyle and backstroke. Neither of the sweeps are propulsive, but rather, they serve the arm to catch water before applying a propulsive force. The insweep is the first propulsive movement in freestyle and butterfly while it is the only propulsive movement in breaststroke. The push phase is the propulsive motion in freestyle and butterfly.

It is clear from the above description, that during the swimming motion a great deal of emphasis is placed on the nearly global motion of the glenohumeral joint. The greater the flexibility of this joint, the better the swimmer is able to generate power through the entire pull-through phase.

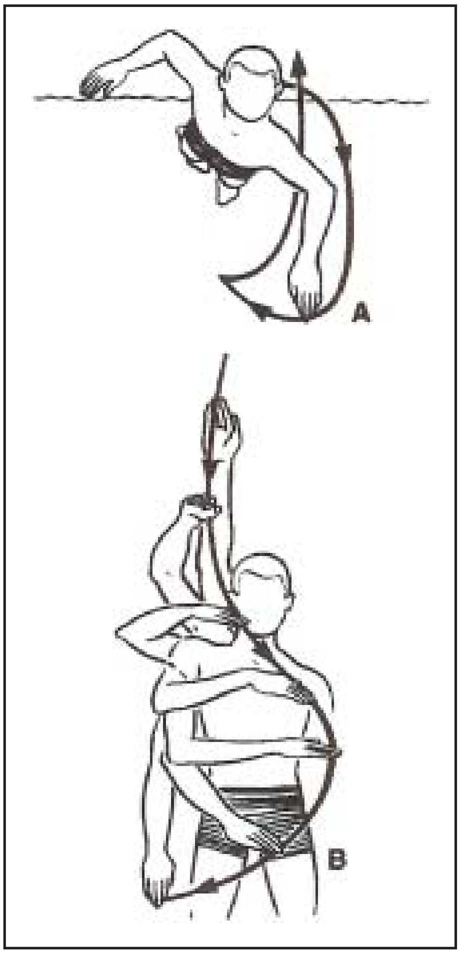

Figure 1. Arm movement during freestyle seen from A the front and B below. Adapted from Allingham 1995; p366[27].

Unfortunately the same flexibility may predispose the swimmer to shoulder joint instability[8].

The kick pattern most commonly used is the two-beat and six beat flutter kick. The two beat flutter kick has one down beat and one up beat of each leg during one stroke cycle. The six beat flutter kick has three down beats and three up beats during once arm cycle[7].

Muscular Demands

Today, the availability of computerised, technological advances in sport science, allows for the analysis of critical information than can lead to improved swimming performance[7]. A discussion of the freestyle stroke follows, as it is often used as a training substitute for the other three strokes[6]. Freestyle muscle activity has been measured both in and out of the water. This has clinical ramifications with regards to rehabilitation, since air provides less resistance than water, thus the pull phase is less stressful[6]. The freestyle stroke depends mainly on the upper extremity for forward propulsion. The adductors and internal rotators largely dominate the pull phase, with force being provided initially by the pectoralis major clavicular portion followed by the latissimus dorsi. Assistance is provided by the serratus anterior and the internal rotator functions of the subscapularis and teres major[6].

Efficient recovery is based on the participation of the external rotators and body roll. Recovery is a small muscle dependant movement with the rhomboid and middle trapezius retracting the scapula as the posterior deltoid, teres minor and infraspinatus externally rotate the shoulder. Shoulder abduction is performed by the middle deltoid and is assisted by the supraspinatus. The main role of the supraspinatus is to stabilize the humeral head in the glenoid thereby allowing the rotator cuff to act efficiently off the base of support created by the scapula stabilizers[6]. In mid recovery for hand entry preparation, the serratus anterior and upper trapezius rotate the scapula upward for shoulder stabilization. During swimming the serratus anterior has been demonstrated to function at 75 percent of its maximum test ability. Due to the repetitive nature of swimming, the lack of sufficient rest phase will inevitably lead to some fatiguing of the serratus anterior[6].

Body roll cannot be underestimated during swimming. During each freestyle stroke, the upper body will roll through nearly 160 degrees[7]. This roll of the torso produces large forces that pull the hand and arm through the water and is a result of the large paraspinal muscles of the back and the abdominal musculature[7]. Perhaps the greatest difference between elite and novice swimmers is the lack of body roll and therefore power in the latter. The efficient use of the body roll helps to decrease the form drag associated swimming as the cross sectional area of the body pushing through the water is decreased with its efficient use.

The kick component for freestyle, butterfly and backstroke is performed by the repetitive movements of hip flexion and extension, knee flexion and extension, ankle plantar and dorsi flexion. The power of the thigh and calf muscles, through the kicking action are purposely timed to enhance and provide power to body roll and therefore, pull-through power[7]. Lumbar spine mobility during the kick is also important. In contrast the breaststroke kick begins with hip and knee flexion. The knee then extends and abducts and brings the ankles together at full knee extension. At the termination of the kick the ankles are plantar flexed.

Common Spinal Injury Sites, Diagnosis and Management

Shoulder Neck Complex

Shoulder

As there are muscles common to both shoulder and neck function, injuries to the shoulder may potentially effect the neck, and should not be ignored. This section will discuss the shoulder and neck. The majority of swimmers who suffer shoulder impingement suffer because of glenohumeral instability[4,9-10]. In the unstable glenohumeral joint the humerus abnormally translates on the glenoid leading to instability. This instability causes the rotator cuff muscles to tighten to stabilize the joint. This is further complicated by the increased flexibility noted in swimmers. The increase in shoulder flexibility correlates directly with swimming speed[11]. Although important for performance, if unattended, these changes could reduce stability of the glenohumeral joint, via increased capsuloligamentous laxity, thereby causing an increase in rotator cuff activity to stabilise the joint[11].

The high reliance upon the shoulder adductors and internal rotators for forward propulsion results in excessive activity and development of the anterior chest and internal rotator muscles. Ultimately this creates internal and external musculature imbalance, thus creating the potential for anterior translation during period of co-contraction and hence, the characteristic posture noted in swimmers[6]. Electrical activity measured in 25 breaststroke swimmers showed an increase in activity of the internal rotators muscles in swimmers with painful shoulders. There was decreased activity in the teres minor, supraspinatus and upper trapezius muscles. These factors increased the risk of impingement[10]. The muscles that performed the greatest work in the normal shoulder are the muscles most likely to fatigue, they being the serratus anterior and teres minor. If left unattended, it could potentially encourage the forward translation of the humeral head causing a relative position of impingement[10].

With both freestyle and butterfly strokes, the supraspinatus and biceps tendon are called upon to work heavily. The supraspinatus tendon passes over the humeral head directly beneath the coracoacromial arch laterally as does the biceps tendon anteriorly. As the result of muscular imbalance in the form of a loss of medial scapular stabilizers, the arm can adopt a position of abduction and forward flexion throughout the swimming stroke. In these positions, the tendons of the supraspinatus and bicep can be stressed throughout a region of the tendons referred to the avascular zone[3]. The effect of loading tendons in this region of hypovascularity has been said to predispose tendons to inflammation, mechanical impingement and ultimately partial or complete substance tears[3]. Persistent inflammation causes scarring and / or hypertrophy of the affected tissues that may act as a mechanical irritant to perpetuate the problem[11]. Thus the "swimmers shoulder" has the potential to become a debilitating chronic injury. This process can continue into middle age, where chronicity and bony changes, consistent with erosion and osteophyte formation on the anterior inferior surface of the acromion can occur[3].

Swimmers have a tendency to be selectively hypermobile in the shoulder with the exception of a tight posterior capsule[2]. When the posterior capsule is tight, the hypermobile joint may cause a functional anterior translation of the humerus. During the swimming stroke application of force to the palm, the hand propeller, results in a vector thrust at the shoulder in an anterior direction, thereby exacerbating anterior shear[8].

The sustained maximal ability to propel the body through the water may lead to dysfunction of the scapulothoracic muscles, as seen by winging of the scapula[9]. The scapulothoracic muscles are responsible for positioning the scapula and therefore the glenoid[11]. This results in less concavity compression needed by the rotator cuff. The dysfunctional change in the stabilisation of the scapulothoracic articulation allows forward rotation of the shoulder, exacerbating any anterior instability. Endurance based swimming workouts may not only fatigue the scapula-positioning muscles but also the rotator cuff muscles[11].

Another cause of shoulder pain is a tear in the glenoid labrum[12]. The labrum is a fibrous structure joined to the glenoid fossa. Its major function is to deepen the concavity of the glenoid fossa, act as the origin for the glenohumeral ligaments and has a role in resisting anterior translation of the humeral head. Tears in the labrum can result from repetitive overhead movements and rotator cuff fatigue that causes forward translation of the humeral head via the mechanism previously described. In the presence of instability, a loss of attachment of the inferior glenohumeral ligament (off the anterior-inferior glenoid rim) can occur. These changes result in clicking, catching or locking of the shoulder. The pain from a labrum injury tends to be maximal midway through the pull phase of the stroke[12].

Although often overlooked, the differential diagnosis of shoulder pain in aquatic athletes should include thoracic outlet syndrome[13]. Freestyle, butterfly and backstroke all require a controlled repetitive power motion at the very extreme of abduction and external rotation of the shoulder. Tightness and pain about the shoulder, neck and clavicle at the hand entry position should alert the physician to the possibility of thoracic outlet syndrome. A common but subtle presenting complaint is the inability to keep fingers together and control the movement of the hand during the pull phase of any of the four strokes. These symptoms are attributed to the loss of strength of the intrinsic muscles of the hand, representing a compromise of the C8 and T1 nerve roots, the medial cord and the ulnar nerve. Compromised vascular structures give symptoms of coolness and pain (subclavian artery occlusion) or a feeling of engorgement or fullness (subclavian vein occlusion)[13].

Therefore several different abnormalities of function can contribute to "swimmers shoulder". These abnormalities include laxity of anterior-inferior caspuloligamentous and muscular structures leading to anterior instability, avascularity of the supraspinatus and biceps tendon, tendonitis and impingement that is exacerbated by scapulothoracic dysfunction. Thoracic outlet syndrome and neck dysfunction commonly refer pain to the shoulder[8].

Cervical Spine

The neck and its related structures often cause radiating pain to the shoulder joint[8]. Younger age groups are less likely to be subjected to cervical spine degenerative disease. However in the older swimmer, disc dysfunction and spondylosis could impinge on nerve roots, particularly those at C4, C5 and C6 levels, resulting in radiating pain to the shoulder joint and beyond. The athlete subjected to herniation of a cervical nucleus pulpous at C5 to C6 or may present with pain, numbness and not uncommonly, weakness in the large motor groups surrounding the shoulder girdle. Such a deficit would make swimming difficult due to the additional load placed on the neck. This would be especially true of the butterfly stroke.

The neck is also subjected to sustained and repetitive movements, which can have implications for overuse injury. 55% of total cervical movement (especially rotation) is provided by the atlanto-axial joint (C1-C2), 5% by the occiput-atlas joint (C0-C1) and the remaining 40% is spread between C2-C6[4]. A study by Guth found that there was a greater mean range of cervical rotation in 14-17 year old swimmers than non-swimmers. In this study, the analysis was made using goniometric measurement of cervical rotation. This result supported the concept that active motion through sporting activity will contribute to a greater degree of flexibility[22].

If one considers the number of strokes a freestyle swimmer takes, i.e. up to 5000 strokes per session and they breathe every 3 strokes then the swimmer would be turning their head 1667 times to breath per session. This is further complicated when the swimmer only breathes unilaterally for the entire session, creating muscle imbalances. Deviating the head from the axis of rotation i.e. looking or breathing forward repetitively can cause unnecessary neck problems due to the neck adopting an extended and rotated position, which is known to stress the neck[19]. The resultant overuse of a hyperextended cervical spine can predispose the athlete to cervicogenic based headaches[23-24].

Neck over-rotation loads cervical spine ligaments and muscles, which encourages asymmetrical development. The face emerges from the water into an air pocket at the bottom of the bow wave, which is created by the head pushing through the water in the same manner as a boat. Due to the protection of the bow wave, swimmers only need minimal rotation of the head to obtain a breath[22]. Poor body rotation results in over-rotation of the neck in order to breathe. If the body is well rotated along its long axis then there is no requirement for the neck to over-rotate. Contributing to this error can be the practice of breathing unilaterally. Breathing only to the favoured side leads to muscular imbalances within the neck, particularly in rotation. Such muscular imbalance may be aggravated by forward head carriage, as the axis of rotation changes resulting in greater body and cervical sidebend and extension to compensate for lost rotation range of motion[20]. Conversely, breathing to the "bad" side may not rotate the body enough potentially contributing to over-rotation of the neck. Thus, bilateral breathing should be encouraged when possible.

Backstroke swimming requires the prolonged contraction of the anterior neck to keep the face above the water line, a position, which may predispose cervical spine hyper flexion[25]. These muscles are prone to fatigue and can result in muscle soreness afterwards. Poor body rotation places added pressure on the shoulders by not allowing them to be deep in the water, thus not allowing them to trace the required "S" shaped curve. This in turn can affect the neck by increasing the strain of anterior structures and encourage the forward head carriage posture[19]. Practitioners noting such posture should liase with the swim coach in order to improve the technical aspects of the swim mechanics that lead to the maladapation.

By contrast, breaststrokers must maintain the head and neck relative to the thorax. The swimmers should rise for a breath from under the water with the body as one unit. The head should not be hyperextended to breathe as it predisposes to cervical facet joint compression and it slows the swimmer down as it forces the hips to drop thus creating more drag[6].

It is likely that poor control of neck flexors would also contribute to such a scenario.

The butterfly stroke relies greatly on timing and appropriate sequencing of events. The most common error is breathing too late, while both arms are already out of the water. This is an awkward position as the shoulders are directed down and forward with the neck and head tilted up resulting in hyperextension of the neck. As with breaststroke, the butterfly stroke swimmers should maintain proper alignment of the head, neck and back when breathing. A weak kick, poor body strength, or a combination of both may result in imperfect clearance of the head and face out of the water causing the swimmer to hyperextend in order to breathe, resulting in possible neck hyperextension injury.

Cervical vertebral movement is vital for effective, pain-free head turning in the recovery phase with the freestyle stroke[6]. Neck extension is required in breaststroke and butterfly strokes. Like the low back, upper limb muscular imbalances should be assessed and corrected[17].

Treatment and Rehabilitation of the Shoulder and Cervical Spine

The initial aim of the practitioner is to reduce the pain and inflammation whilst maintaining function. Rest, Ice, Compression and Elevation (RICE) along with non-steroidal anti-inflammatory drugs (NSAIDS) may be used in the acute phase. Care should be taken with elevation as it can aggravate all mechanical lesions of the shoulder. This is a position adapted by all swimming strokes as well as many of the training drills (i.e. kick board). Modalities like soft tissue massage, ultrasound and electrical stimulation can also help decrease pain. In the chronic case, transverse friction massage may be beneficial. Cross friction promotes increased blood flow, fiber mobility and alignment. It should not be performed on the acutely injured rotator cuff.

Thoracic function, in particular anterior chest muscles and the posterior capsule often need to be stretched to help restore normal motion between internal and external rotators. The latissimus dorsi, pectorals and shoulder internal rotators characteristically shorten and the thoracic curvature increases collectively leading to a loss of extension through the thorax. A scenario that functionally predisposes impingement, this postural adaptation can result in a compressive force in the acromioclavicular joint and eventually, the sternoclavicular joint[14]. Thoracic spine extension is necessary for protecting the shoulder joint from injury. The deltoid can be released, stretched and massaged to reduce upward migration of the humeral head, a factor associated with mechanical disorders of the glenohumeral joint[15]. Muscles should be stretched at least 3-5 times for 15-20 seconds for most benefit[2]. Gentle manipulations and mobilisations of the scapula, humerus, acromioclavicular joint, sternoclavicular joint and cervicothoracic spine should be performed as required[15].

Scapular stabilization is required for shoulder rehabilitation[16]. The aim of this phase is to align the scapula as an appropriate base of support for the action of the rotator cuff muscles. To achieve optimum function the shoulder is held back and down through scapular retraction exercises. Swimmers with painful shoulders have been found to recruit the rhomboid muscle more in the propulsive phase than non injured swimmers[6]. These muscles should be trained to contract in a normal state, which will reduce the forward shoulder posture and allow increased subacromial space. Consideration should also be given to the lower trapezius as it counteracts the upward scapula pull by the upper trapezius, which is active throughout freestyle stroke. The serratus anterior is active throughout the entire stroke cycle and thus must be trained to resist fatigue. Similarly, the rotator cuff muscles are also active throughout the entire stroke range and may also be prone to fatigue related injury[11].

Stroke mechanics should be reviewed in consultation with the swimming coach. Lack of body roll or the hand crossing the midline in freestyle promotes impingement, as extreme internal rotation and adduction is encouraged in this abnormal position. Maintaining a high elbow and breathing consistently to both sides reduces stress in the shoulder and neck by distributing forces on the humeral head more evenly, hence bilateral breathing is recommended. Swimming intensity and volume should be monitored as shoulder muscles fatigue. The use of hand paddles and tethered swimming should be avoided as they have been identified as causative factors in shoulder injuries for swimmers[8]. Other exercises like kicking with a kickboard for long periods not only affect the shoulder but can hyperextend the neck also. The use of dryland exercises such as tricep dips, bicep curls, bench press and shoulder overhead press in the weights room may promote shoulder impingement if performed incorrectly. By contrast, postural instruction for swimming may have long-term benefits. Benefits may include increased propulsion and reduced resistance of water to forward movement. In most cases, form drag can be reduced by the swimmer adopting a swim posture that is 'streamlined' or horizontal from head to toes. Swimmers should also be encouraged to roll their bodies from side to side when swimming freestyle (figure 1) and backstroke (figure 2), thus reducing the tendency of body swinging from side to side as a result of alternating lateral and vertical movements of their arms. Breaststroke (figure

3) and butterfly (figure 4) requires some undulating trunk movement to increase propulsion and this has the potential to cause drag. However this movement increases propulsive force, making the trade-off advantageous for swimming speed. Slicing the hands in the water while swimming freestyle, backstroke or butterfly can reduce wave drag. The recovery phase of the stroke is made over the water and is therefore not a factor. This will also reduce the wave drag in breaststrokers who recover their arms over the water. Frictional drag can be reduced by shaving body hair or wearing swim suits of low friction fabric, designed to fit like a second skin. Such swimsuits have previously caused much controversy at the elite level, as some commentators feel they act as an aid to buoyancy.

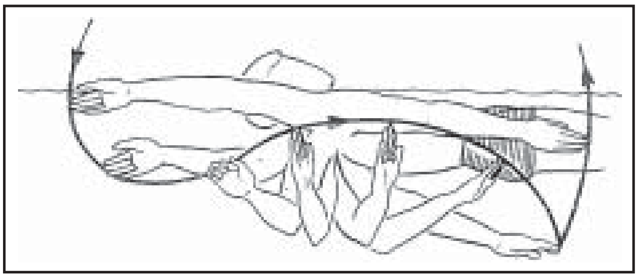

Figure 2. Arm movement pattern during backstroke.
Source: adapted from Costill, et al (1992).

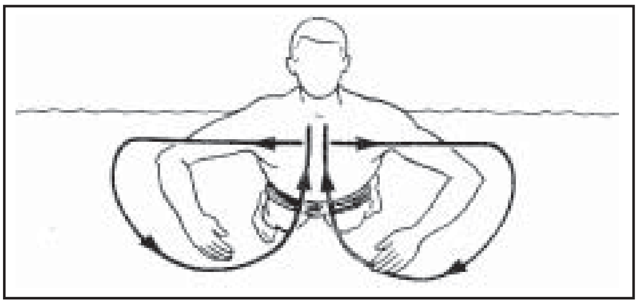

Figure 3. Arm movement pattern during breaststroke.
Source: adapted from Costill, et al (1992).

Surgery maybe considered for swimmers with chronic shoulder pain that does not respond to conservative treatment. A capsule-tightening procedure may be considered for swimmers with instability. Subacromial decompression should be considered only for swimmers who have a type III hooked acromion[16]. The anterior slope of the acromion in this case may reduce the effective space the supraspinatus tendon has, when it slides in shoulder abduction.

Shoulder rehabilitation is also relevant for the cervical spine. Swimmers with neck pain, particularly due to muscle spasm and/or restricted range of motion, are likely to benefit from

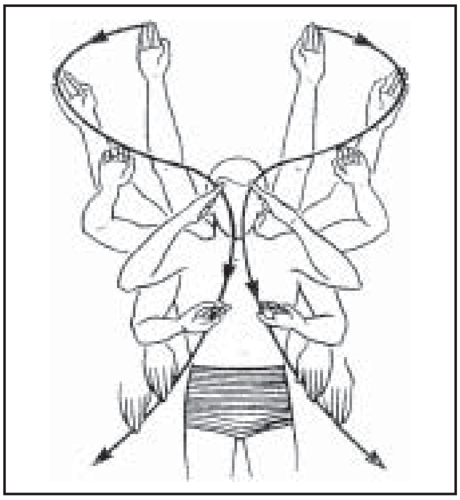

Figure 4. Arm movement pattern during butterfly.
Source: adapted from Falkel, et al (1988).

manipulation and/or mobilisation of the neck and upper thoracic areas[6]. Scapula stability and postural education is important for neck function. Special consideration should be given to the deep neck flexors (longus capitis and colli) and cervicothoracic extensors (semispinalis cervicis and longissimus cervicis)[26]. Motor control via endurance-based exercises should make up the core of cervical spine rehabilitation. Eye-head-neck coordination training through various reflexes should also be considered in those who suffer from neck injuries. Specifically these reflexes include: the cervico-ocular reflex, vestibulo-ocular reflex, cervicocollic reflex, vestibulocollic reflex, optokinetic reflex, smooth pursuit and saccades[27]. Correction of these reflexes can be performed in an unstable environment. With the patient standing on one (or two) legs and on a wobble board, a pen is held in front of the patient so he or she can fix the gaze. The pen is then moved from side to side as the patient follows it freely with their head and eyes, stimulating the smooth pursuit reflex. To stimulate the vestibuloocular and cervico-ocular reflexes, the patient fixes their gaze on the pen but only the head will move in rotation. To stimulate saccadic movements of the eyes, a book or magazine is held in front of the patient and they are asked to read aloud[26].

Lumbo Pelvic Complex

Low back injuries in swimmers most often are caused by repetitive stress during turns and the strain of poor head and body position in the water[2]. Torsional strain can occur when the body does not roll as a whole unit during the stroke causing abnormal loading at the point in the spine where the rolling stops[2]. This predisposes the swimmer to overuse or acute injury or both. Pelvic musculature, particularly tight hip flexors can reduce hip extension resulting in hyperextension of the lumbar spine and anterior pelvic tilt[17]. In addition, anterior pelvic tilting results in the pelvis assuming a lower than normal position in the water, creating increased drag[19]. Disc degeneration may occur in the older swimmer[18]. While this isn't thought to be caused by swimming, it may be aggravated by certain body positions held during various individual strokes.

The hyperextension motion of the lumbar spine seen with butterfly and breaststroke can predispose to facet joint irritation, otherwise known as "Butterfly back syndrome"[18]. The power and range of the kick depends largely on lumbosacral mobility, as well as the flexibility of the hip, knee and ankle joints. Butterfly requires repeated flexion and extension of the trunk. The extension is necessary to elevate the shoulders to obtain clear water for the head in the recovery phase of the stroke. The "Butterfly back syndrome" is made worse if the pelvis is tilted anteriorly as this position will cause facet joint compression. If this compression becomes repetitive and chronic, it may progress to low grade joint inflammation, leading to reflexive spasm of the back muscles and pain can occur[19]. With continued repetitive stress, low back problems like stress fractures of the pars interarticularis (spondylolisthesis) can occur.

Several changes in competitive swimming technique have emphasized the flexibility required of the torso[20]. In the mid 1980's spectators were introduced to the underwater backstroke, where swimmers would dolphin kick almost the entire 50 meter pool length. Although the rules have been modified, the practice of staying underwater for the first 15 meters of a race is now standard[20]. The underwater porpoise motion clearly places stress on the thoracolumbar paraspinous musculature[20]. A change to the breaststroke rules, now allows the head to dip underwater altering the breaststroke technique, whilst simultaneously allowing the heels to break the surface during the kick. As a result, the breaststroke mechanics became similar to butterfly mechanics. Both strokes require considerable flexibility of the thoracolumbar spine.

Research carried out at a London hospital investigated 50 swimmers with lower back pain who regularly competed in butterfly events and found that in this particular group of subjects, there was the high percentage (25%) having minor radiographic abnormalities such as old Scheuermann's disease from repetitive flexion loading of the thoracic spine. These findings could be developmental, traumatic or both[18].

Scoliosis has been found to be quite common in younger swimmers and may be exacerbated by swimming[21]. The incidence of structural scoliosis (deviation > 20 degrees with rotation, rib hump asymmetry) in athletes has been found to be 1.6-2.0%. However in swimmers, it has been found to be about 7%. Considerable controversy exists as to whether competitive swimming may actually worsen the scoliotic curve. It has been speculated that the muscular imbalance between the anterior and posterior musculature, repetitive torsional motion and arm dominance of the adolescent and preadolescent swimmers may cause secondary adaptation in vertebral structure leading to scoliosis[21].

Treatment and Rehabilitation of the Lumbo pelvic complex

Managing swimmers back pain includes assessing and correcting spinal and pelvic joint mobility via various methods that can include manipulative and mobilising techniques. Muscle imbalances, particularly tight hip flexors and erector spinae as well as inhibited gluteals and abdominals, should be assessed and treated for long term improvement[19]. Spinal stability and impaired motor control must be addressed. Motor control skill has been shown to be compromised under challenging aerobic circumstances[29]. The multifidus muscles of the lumbar spine are associated with atrophy in those with acute low back pain. The atrophy was unilateral to the side of pain and at the same level as the palpable joint dysfunction[30]. Spinal stabilisation exercises (sometimes referred to as "core stability exercises") have been shown to prevent multifidus muscle atrophy[31]. Trunk muscle co activation using an abdominal bracing technique has been shown to increase the margin of stability when performing activities[32]. Bracing requires a light contraction (5-10% of patients' maximum voluntary contraction) with the breath not held during the brace[32]. Spinal stability training requires an emphasis on endurance[33], rather than strength and upto three months is often required to prevent chronic pain[34]. Flexibility and mobility are important but this should be emphasised above and below the lumbopelvic spine.

Conclusion

The management of swimming injuries must include prevention based education and activity. Effort should be made to develop a team approach by talking to the swimmer's coach, their support staff and to other practitioners. Such an approach is important in light of the fact that most injuries occur in training and are overuse in nature. Knowledge of swimming biomechanics and the demands placed on the spinal musculoskeletal system should aid the practitioner in the diagnosis and management of injuries as well as gaining the trust of the athlete and coach. Most swimming injuries are minor and can be treated with conservative care. The criteria for return to swimming should include the restoration of joint range of motion, the resolution of oedema, and the return of flexibility, strength and endurance. As chiropractors continue to become involved in the treatment of swimmers at all levels, it is important to keep in mind the detraining effects on the swimmer if they are kept out of the water for any substantial period. Every effort should be made to keep the competitive swimmer “in the water”.

References

1. Richardson AB, Miller JW. Swimming and the older athlete. Clin Sports Med 1991; 10(2):301-18.
2. Kenal KAF, Knapp LD. Rehabilitation of Injuries in Competitive Swimmers. J Sports Med 1996; 22(5):337-47.
3. Kennedy JC, Hawkins MD, Krissoff WB. Orthopedic manifestations of swimming. Am J Sports Med 1978; 6(6):309-22.
4. McLean ID. Swimmer’s Injuries. Aust Fam Physician 1984; 13(7):499-502.
5. McMaster WC. Swimming injuries: An overview. Sports Med 1996; 22(5):332-6.
6. Souza TA. The Shoulder in Swimming. In: Souza TA. Sports injuries of the shoulder. Conservative Management. Churchill Livingstone Inc. 1994. p107-124.
7. Troup JP. The physiology and biomechanics of competitive swimming. Clin Sport Med 1999; 18(2):267-83.
8. McMaster WC. Shoulder injuries in competitive swimmers. Clin Sport Med 1999; 18(2):349-59.
9. Rupp S, Berninger K, Kopf T. Shoulder problems in high level swimmers: impingement, anterior instability, muscular imbalance? Int J Sports Med 1995; 16(8):557-62.
10. Ruwe PA, Pink M, Jobe FW, Perry J, Scovazzo ML. The normal and the painful shoulders during the breaststroke. Am J Sports Med 1994; 22(6):789-96.
11. Weldon EJ, Richardson AB. Upper Extremity overuse Injuries In Swimming. Clinics in Sports Medicine 2001; 20(3):423-37.
12. McMaster WC. Anterior glenoid labrum damage: a painful lesion in swimmers. Am J Sports Med 1986; 14(5):383-7.
13. Richardson AB. Thoracic outlet syndrome in aquatic athletes. Clin Sport Med 1999; 18(2):361-75.
14. Innes KA. The Effects of Gait on Extremity Evaluation. In: Hammer WI. Functional Soft Tissue Examination and Treatment by Manual Methods. New Perspectives, 2nd Edition. Gaitherburg, MD: Aspen Publishers, 1999. p357-68.
15. Wise K, Huff L, Brady DM. Shoulder Tendinitis/Bursitis. In: Huff L, Brady DM. Instant Access to Chiropractic Guidelines and Protocols. Mosby, Inc. 1999 p137-142.
16. Kammer S, Young CC, Niedfeldt MW. Swimming Injuries and Illnesses. Physician Sports Med 1999; 27(4):51-4,57-60,109-11.
17. Liebenson C. Integrating Rehabilitation into Chiropractic Practice. In: Liebenson C. Rehabilitation of the Spine. Baltimore, Williams and Wilkins. 1996, p13-43.
18. Cameron JM. Medical problems in competitive and recreational swimming. In: Payne SDW. Medicine Sport and the Law. Blackwell Scientific Publications. 1990. p285-289.
19. Chek P. Stabilisation for Propulsion: Abdominal training for Swimming. The Official Magazine of the Strength and Conditioning Association 1996; 4(3):18-21.
20. Ferrell MC. The spine in swimming. Clin Sport Med 1999; 18(2):389-93.
21. Becker TJ. Scoliosis in swimmers. Clin Sport Med 1986; 5(1):193-246.
22. Guth EH. A Comparison of Cervical Rotation in Age-Matched Adolescent Competitive Swimmers and healthy Males. J Orthop Sport Phys Ther 1995; 21(1):21-7.
23. Sjaastad O. Cervicogenic headache: the controversial headache. Clin Neurol Neurosurg 1992; 94Suppl:S147-9.
24. Bogduk N. The Anatomical Basis for Cervicogenic Headache. J Manipul Physiol Therapeut 1992; 15(1):67-70.
25. Hopkins TJ. Rehabilitation of Athletes following spine injury. Clin Sport Med 1993; 12(3):603-19.
26. Murphy DR. Sensorimotor training and cervical stabilization. In: Murphy DR (ed.) Conservative Management of Cervical Spine Syndromes. New York: McGraw-Hill, 1999:607-40.
27. Murphy DR. Normal function of the cervical spine II: neurophysiology and stability. In: Murphy DR (ed.) Conservative Management of Cervical Spine Syndromes. New York: McGraw-Hill, 1999; 45-70.
28. Allingham C. The shoulder complex. In: Zuluaga M, Briggs C, Carlisle J, et al. Sports Physiotherapy, Melbourne, Churchill Livingstone, 1995; 366-8.
29. McGill SM, Sharratt MT, Seguin JP. Loads on the spinal tissues during simultaneous lifting and ventilatory challenge. Ergonomics 1995; 38:1772-92.
30. Hides JA, Stokes MJ, Saide M, Jull Ga, Cooper DH. Evidence of lumbar multifidus muscle wasting ipsilateral to symptoms in patients with acute/subacute low back pain. Spine 1994; 19(2):165-72.
31. Hides JA, Richardson CA, Jull GA. Multifidus muscle recovery is not automatic after resolution of acute, first-episode of low back pain. Spine 1996; 21(23):2763-9.
32. McGill SM. Building better Rehabilitation programs for Low Back Injuries. In: McGill SM. Low Back Disorders: Evidence Based Prevention and Rehabilitation. Human Kinetics Publishers, Champaign, Illinois, 2002; 205-22.
33. McGill SM. Low back exercises: evidence for improving exercise regimens. Physical Therapy 1998; 78(7):754-64.
34. Manniche C, Lundberg E, Christensen I, et al. Intensive dynamic back exercises for chronic low back pain. Pain 1991; 47:53-63.