Introduction to competitive swimming

Goals of this part are:
- giving the reader a comprehensive approach to swimming
- insight into physiotherapeutically-relevant aspects of the sport
- epidemiology and general information on injuries

Swimming is an individual sport with high demands to physique and psyche of an athlete. It is a complex sport that demands high dedication and strong-willingness to succeed.

Swimming comprises four major types of stroke:
Butterfly, swum in prone position
Backstroke, swum in prone position
Breaststroke, swum in prone position
Freestyle, swum in prone position
And medley, comprising all four (in the above listed order)

Because of a swimmer performs in a different environment than on-land, it has specific characteristics that are poorly investigated up to this date (Loozen, 2009).

The daily training distance averages from 5000 to 8000 meter per day.
In 1 year a swimmer may move the shoulder to its extreme range of motion in about 1 million arm strokes (Blanch, 2004). Since the frequency of strokes depends on the stroke length, females tend to show higher numbers of total strokes (1.6 million according to O'Donnell). The number of revolutions of the shoulder joint is in swimming greater than in any other sport (Allegrucci).

Despite the four different types of stroke, the major part of training is swum in free-style, because it is the fastest swimstyle and allows best gain of kilometers (Veld&Hoekstra, 2008).
A training routine consists of a swim-part (most often 66%) and land-training (running, gymnasium, prevention).

Overall, there is a higher percentage of hypermobile people in the swimming population than average population (Stoel, 2010). It is not clear yet whether hypermobile people tend to swim or whether swimming causes the development of hypermobility (Lambalk, 2010).

Upper arm motion during freestyle stroke
In order to understand rehabilitate the swimmer correctly one must understand the how a swimmer uses their body to swim and what structures can be harmed by these motions.

This can be achieved by what coaches call ‘keeping a high elbow’ (i.e. that the plane of the elbow is above the plane of the hand) (see Fig. 1) (Reinicke, 2009, Stoel, 2010). This position of a ‘high elbow’ requires considerable flexibility of the shoulder girdle. The swimmer internally rotates the humerus in high levels of elevation whilst flexing the elbow to anchor the hand and forearm.

Motivation and attitude:
Swimming is an individual sport. A high percentage of swimmers believes the “No pain, no gain”-Motto. This is in itself not problematic, yet the line between healthy and non-health pain is often not recognized by swimmers (Pink). Therefore, unhealthy conditions are further aggravated by the attitude of the athlete.

Pathologies termed painful shoulder syndrome
In general speaking, the term swimmers shoulder comprises a variety of pathologies with multidimensional causing factors (Blanch, 2004). This means there are several pathologies that may be present in a swimmer presenting himself with shoulder pain. It is the purpose of this section to present the most important pathological conditions.

An estimated 70% of competitive swimmers suffer from shoulder pain syndrome at least once in their career. It was further observed that the prevalence of shoulder injuries increases with age (McMaster, 1999). This implies a gradual onset of health problems, as well as a result of overuse.

Because the painful shoulder syndrome is a complex health problem, it is difficult to estimate numbers of incidence. It is in the opinion of the research team that it is a complex condition that gradually builds up over years, with a variety of predisposing factors established before the actual health problem takes place. However, in a study of Goekint et al., 2006, 73% of all injuries in competitive swimmers concerned the shoulder area.

Brief description of pathologies and approaches to assessment:

Tendinopathy of Biceps tendon (Weldon, 2001, Johnson et al., 2009, Kennedy et al. 1974)
Suggested test: Speed's test (Bansal et al., 2006, Calis et al., 2000)

Labrum tears (Sherwin, 2006, Brushøj et al., 2007, McMaster, 1986, Beltran et al., 2003)
Crank test Parentis et al., Myers et al., Nakagawa et al., McFarland et al., Morgan et al., O'brien et al)
Swimming requires a high ROM in the shoulder joint. Therefore, swimmers aim at maximizing the active ROM in the shoulder joint. This is mainly done by increasing passive ROM. This increases the chance of instability (Yanai & Hay, 2000). Several aspects come to instability:

− Laxity of ligaments (Weldon & Richardson, 2001)
− Muscular dysbalance (McMaster, 1999)
− Muscular overuse (Weldon & Richardson, 2001)

Suggested tests:

Suggested tests: Serratus anterior functionality (Cools, 2007), Scapular configuration in observation (Cools, 2007), Kibler Test (Rupp et al., 1994, Kibler 1998)

Risk factors developing shoulder pathologies (according to Stoel, 2008):
− Training setup (intensity, frequency) → The higher the more likely
− Paddles
− Impaired strength shoulder girdle musculature
− Bad overall posture
− Technical errors (during stroke)
− Previous/present shoulder pathologies
− Dry-land-training (gymnasium)
− Swimming on higher competitive level
− Mid-distance and sprint swimmers

However, the exact relation between these aspects has not been investigated properly, as discussed in the systematic review of the researchers.

Investigations of swimmers of SV Limmat Sharks
Description of warm-up:
Because swimming is a not-so-well investigated sport, and lack of financial ressources, the infrastructure of swim clubs is semi-professional. Compared to football clubs (e.g. U-23 Gelsenkirchen, Germany), there is few investigation. The SV Limmat currently employs a massage therapist attending trainings once a week. Therei s no physiotherapist assigned to the
team, nor a doctor. However, athletes tend to consult the same therapeutic team (personal communication swimmers and coach, SV Limmat 2009).

At the training sessions of the Limmat sharks in Zürich we witnessed their general warm-up. It took around 20 minutes, consisting mainly of light tera-band exercises for the shoulder:
- external rotation
- external rotation in 90 degrees,
- isometric rowing exercise
- specific pull through step of stroke for swimming
- shoulder rotations in 90 degrees of forward flexion
- PNF opposing pocket to 135 degrees of abduction
- tricep exercise

Furthermore core stability exercises were done, these included:
- sit-ups
- oblique sit-ups
- back extensions
- back extensions w/ rotations
- side flexion.

Stretching is also done in this warm-up which included;
- forward flexion stretching on wall (ventral capsule)
- dorso-lateral capsule stretching (elbow in 90, arm pulled over head)
- posterior capsule stretch

Assessment findings:
An assessment performed with the swimmers of the SV Limmat Zurich. The following numbers indicate signs of a certain pathology assessed by the researchers. They are not confirming a pathology, only indicating the possibility of the presence of a certain condition! (Were assessed using algorithms following the HOAC II standard).
5% indicated labrum tears
35% indicated impingement syndrome
70% indicated supraspinatus tendinopathy
70% indicated scapular dyskinesia (i.e. difficulties to maintain scapular control during specific motions)
82% indicated muscular imbalance of the shoulder complex (e.g. anterior superior position of humerus)
88% showed signs of shoulder instability

We further interviewed several athletes as well as their coach. Main points concluded were:

− there is little anatomical knowledge in the coach
− certain dogmas as (the more stretching of the glenohumeral joint the better you swim) are still present
− stretching is not performed tailored to the individual
− swimmers strongly believe in the “No pain, no gain” idea (70% indicated this, personal communication swimmers, 2009)
− there is a tendency to place success over health (personal communication swimmers, 2009)

Prevention of shoulder injuries:

In order to reduce the injury rate in competitive swimmers, we identified several hypothesis: “Important factors causing shoulder pathologies are muscular dysbalance with weakness of external rotation, scapular dyskinesia and core stability deficits” (Stoel, 2008, Cools et al. 2007, Blanch, 2004)

Therefore, exercises aim at improving the respective aspects. It must be noted, that we took into consideration the overmotivation of swimmers, tending to look for intensity rather than correct execution of exercises (Lambalk, 2010, Pink, 2005).

A 12-exercises program was developed according to the demands of the SV Limmat. Special attention was given to communicability of an exercise, purpose and materials required.

Exercises were selected with the following methods.

− Recommendations from Jacqueline Stoel, PT of the NZA
− Exercises proposed for specific goals (e.g. scapular stability) recommended by literature (as much focussing on swimmers as possible)
− Recommendations from Stephan Roethke (PT Schulthess Klinik and PT of the German Beach-Volleyball team), Zurich

Literature research was performed with the intention of finding preventative shoulder exercises in swimmers on Pubmed, Google Scholar and Medline. A difficulties the researchers encountered was lack of literature or articles showing incomplete approaches (lack of explanation, lack of results, lack of instruction).

Furthermore, selection criteria concerned applicability in the training environment of the SV Limmat Sharks, as well as specifications and expectations given by Dirk Reinicke, head coach of the SV Limmat.

The underlying causes we addressed were investigated and identified in a systematic review by the research team. It must be stated, however, that level of evidence for this specific sport is low and therefore remains with several assumptions.
Another focus lay on giving both swimmers and coaches two tools:
a more thorough understanding of what they are doing (both in prevention exercises as well as in
training overall), and an emphasis and recommendation on more communication

<table>
<thead>
<tr>
<th>Name of exercise</th>
<th>Aspect</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Retraction shoulder complex</td>
<td>Postural adjustment</td>
<td>Schulthess clinic, 2009</td>
</tr>
<tr>
<td>2. Retraction shoulder blades</td>
<td>Postural adjustment</td>
<td>NZA, 2010</td>
</tr>
<tr>
<td>3. Mobility of thoracic spine</td>
<td>Mobility</td>
<td>NZA, 2010</td>
</tr>
<tr>
<td>4. Posterior capsule stretch</td>
<td>Mobility</td>
<td>Lauder et al., 2008</td>
</tr>
<tr>
<td>5. Scapular clock</td>
<td>Scapular awareness</td>
<td>Kibler, 2000</td>
</tr>
<tr>
<td>6. Pushup Plus</td>
<td>Strength of scapular stabilizers</td>
<td>Decker et al., 2009, Pink &amp; Tibone, 2000</td>
</tr>
<tr>
<td>7. Dynamic hug</td>
<td>Strength of scapular stabilizers</td>
<td>Decker et al., 2009</td>
</tr>
<tr>
<td>8. Horizontal forward flexion</td>
<td>Strength of scapular stabilizers</td>
<td>Coles et al., 2007</td>
</tr>
<tr>
<td>9. Horizontal abduction</td>
<td>Strength of scapular stabilizers</td>
<td>Coles et al., 2007</td>
</tr>
<tr>
<td>10. Horizontal external rotation</td>
<td>Strength of scapular stabilizers</td>
<td>Coles et al., 2007, NZA, 2010</td>
</tr>
<tr>
<td>11. External rotation standing</td>
<td>Strength rotator cuff</td>
<td>Schulthess clinic, 2009</td>
</tr>
<tr>
<td>12. Cycling in the air</td>
<td>Core strengthening</td>
<td>Mensendeck system, 2005</td>
</tr>
</tbody>
</table>

**Table of exercises**

**Treatment**

There has been little consensus on efficient treatment methods of shoulder pathologies in swimmers (Weldon & Richardson, 2001) and was not focus of this intervention.