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11.1 Introduction

Water polo is a mixed sport that contains swimming, full contact, and overhead throwing at the same time. It has bursts of very high-intensity demands (15 s) followed by low-intensity intervals that make it very physiologically demanding. Playing area is 30 m × 20 m length, to 10–20 m width, depending on the level of competition, in a 2 m minimum pool depth. Teams have six field players and a goalkeeper. The ball diameter is 68–71 cm for men, and it weighs from 400 to 450 g, making it difficult to handle and, of course, hard to be hit by. The object of the game is to score goals by putting it on the opponent's net. You can attack any player holding the ball (that cannot be immersed underwater), making it a tough collision sport. To moderate contact if a player is attacked without the ball, the offensive player is excluded for 20 s. Having three consecutive exclusions, means leaving permanently. Game is separated in four quarters of 8 min at elite level, with a 2 min interval between them [1]. Time possession by each team is 30 s, and if

no shot is taken, a free throw is awarded to the opposite team, making this game very quick and demanding.

It was originated first described in 1860 as an aquatic equivalent of rugby and is the oldest team sport included in the Olympic Games. It is played since 1900 in its male version but started its woman competition lately at the Sydney Olympic Games in 2000 [2].

Swimming in water polo is different because players either carry the ball or “see” the field while playing (Photo 11.1) so it is always heads up, with neck extension. Body rolling is not performed neatly, also the stroke is shorter. Swimming postures involve greater shoulder abduction, higher elbow position that places a heavier load on the joint with less stroke efficiency [3].

Overhead shooting is also different, first, the ball is larger and heavier, then there is no support on the water. Anyway, the speed of the water polo shot can reach up to 70/km/h [4]. Another shoulder movement is passing; this is a low-intensity movement of the shoulder and could also be done by the non-dominant arm, that must be trained for that. All these movements could be stopped anytime by the opponent, as when the ball is held by a player, contact could be made anywhere. So, shooting or passing nearly always got to be compromised by a defender, making these movements prone to contact lesions and always shorter and quicker than regular shooting (Photo 11.2).

Another distinct feature is a rotational movement known as the “eggbeater kick” [4]. Water

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Photo 11.1 “Heads up” swimming

polo players, especially the goalkeeper, must maintain an above surface playing position, allowing to stand above water at different heights and move laterally, performing specific maneuvers for each player. No player is allowed to touch the bottom of the pool at any time. This specific drill is performed by rotating clockwise and counterclockwise in opposite fashion between both legs, creating high loads on groin adductors and hip, and especially on the medial side of the knee. Its dynamics may cause medial collateral laxity and patellofemoral pain, similar to breaststrokes [5, 6].

11.2 Epidemiology

Water polo was ranked fifth, in the proportion of injured athletes on 2016 Olympic [7] with an injury mean ranging from 9.6/12.9 per 100 players, while in the FINA world championship it was 15.9 [7–9]. That makes us know that it is a tough contact sport. Injury rate has been increasing from 2008 to 2016, doubling its frequency [7] in a review of 8904 player matches, during FINA

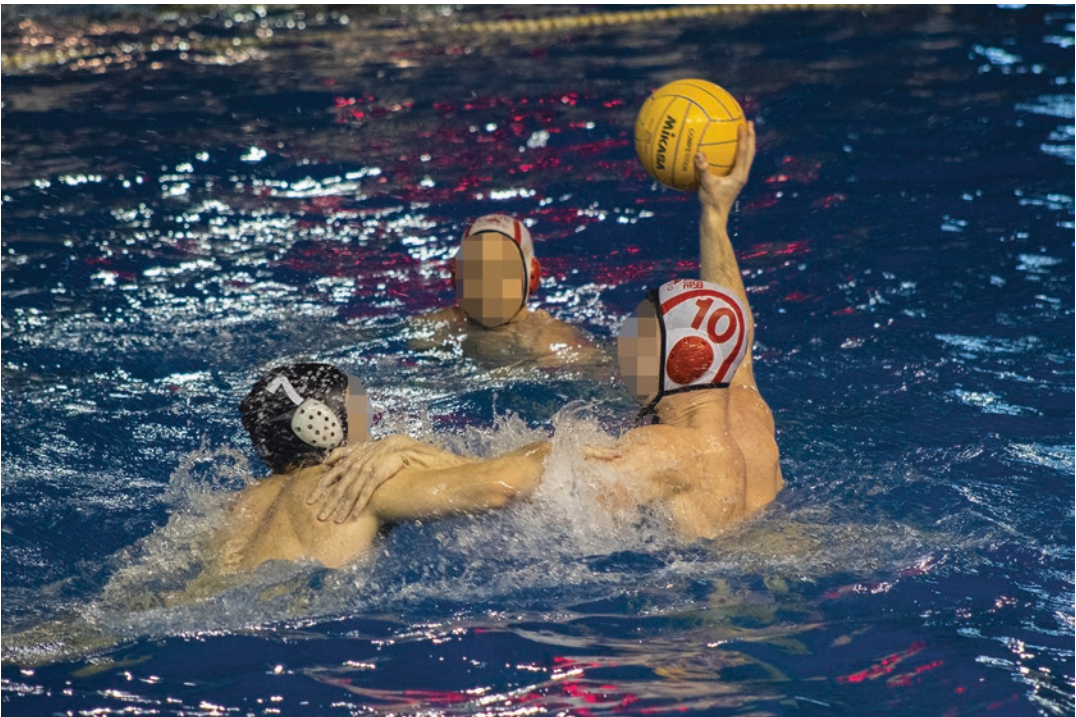


Photo 11.2 Overhead shooting compromised by a defender

world and Olympic Games. Head injuries were first with a 25.6% of the overall count, followed by hand, finger, trunk, and shoulder. More than 57% were contact lesions between players and 13% with an object, so a total of 70% acute injuries. However, this is a very specific cohort of injuries that gives us concern about ruling on contact control, and probably fair play. However, it does not give us a general picture of lesion prevalence.

Regarding surveillance of athletes in longer periods of time, a report on a 4-year epidemiology, in sub-elite water polo players [9] showed that shoulders are the more affected (25%) followed by thoracic, lumbar area (17%) followed by hand, finger, wrists, then by hip, groin, knee, and elbow. This difference is explained by the nature of the sport that may have a typical training week, with up to five water polo-specific sessions, two to three swimming-specific sessions and three weight training sessions [3]. Playing needs high training loads that put overuse lesions always near.

11.3 Sports-Specific Illness

Water polo is prone to the same illnesses of any aquatic sports such as infectious respiratory or gastrointestinal tract, but usually, otitis and allergy/skin issues are the most common. Eye irritation is also very common because the use of goggles is not allowed [6].

11.4 Head Injuries

Water polo is a physical sport with a great amount of contact between players and minimal protective equipment. According to the Federation International of Natation (FINA), only a swimming cap with malleable ear protectors may be worn [1].

The head and face are the most commonly injured body parts, usually as a result of physical contact [10, 11]. Contusions and lacerations are common, as well as eye injuries [12]. There also is a risk of fracture to facial or orbital bones.

There are three main categories of eye injuries seen in water polo: corneal abrasions, hyphema, and blow out fractures [13, 14].

Traumatic eardrum perforation is also common despite the use of ear protectors [15]. This typically occurs when a cupped palm slaps the side of the head, causing a sudden rise in pressure in the ear canal [10]. The use of molded earplugs, and swim caps can help these players continue to train and play while minimizing water exposure and risk of infection [10, 15].

According to the International Dental Federation (FDI) water polo is classified as a medium-risk sport for dental injury; however, according to one survey, only 7.7% of athletes wear mouth guards [16]. Nearly 50% of those players reported having witnessed a water polo-related dental injury and 21% reported that they had suffered a dental injury from the sport, most commonly a tooth fracture. In another study, a survey of 415 Swiss water polo players reported that 21% of all respondents had suffered a dental injury during play over their career [17].

11.5 Concussion in Water Polo

Water polo is a highly physical contact sport. The incidence and prevalence of concussion in the sport are not well known.

Concussions are of particular concern in water polo, with up to 36% of players reporting a history of prior concussion on a recent survey of USA Water Polo members and an average of more than two concussions per person. Goalkeepers are again at particularly high risk, with 47% reporting at least one prior concussion. Patterns of head impacts that goalies suffer are quite different than those reported by other positions, as most head impacts come from the ball rather than from player contact. In contrast, other position players report that head impacts result from a combination of the ball and hits by other players [18].

The average number of reported concussions increase with higher competition level and the number of years played [18]. An investigation of collegiate varsity men's water polo found that a single team sustained an average 18.4 head impacts per game [19].

Cecchi et al. [20] in a collegiate club water polo team were monitored during one season of

intercollegiate competition. Smart Impact Monitor (SIM-G) sensors (Triax Technologies; Norwalk, CT) found that men were impacted more frequently at the back of the head, relative to the front, right, or top and by the opposing player's limb or torso, relative to their head or the ball. Women were impacted more frequently at the back of the head.

A growing body of evidence suggests that chronic, sport-related head impact exposure can impair brain functional integration and brain structure and function. In a study using cap-worn inertial sensors to measure the frequency and magnitude of head impacts sustained by 18 intercollegiate water polo athletes monitored over a single season of play, report that the frequency and magnitude of head impacts sustained during a season of water polo competition were strongly associated with changes in whole-brain functional connectivity, particularly a pattern of slow-wave synchrony associated with a loss of inhibitory control [21].

11.6 Shoulder Injuries

Water polo is an extremely demanding sport that involves several conditions that could lead to a shoulder injury. Moreover, the strokes are different from the ones of a freestyle swimmer. The

statistics on shoulder damage are challenging due to its variability.

Regarding shoulder injuries, complete rolling of the body is not possible because players have to carry the ball in front or see the field; therefore, they need to put their head out of water frequently, doing abduction, high elbow position usually in a short explosive burst of speed, differing from regular swimmers' kinematics.

Overhead throwing also has different kinematics. The ball is bigger and heavier. Speed is generated with a kinematic chain suspended in an eggbeater boost kick which is no match to the counterreaction of a baseball pitch (Photo 11.3). Trunk moves from hyperextension to 20° of flexion and lateralization, with shoulder behind the body, in maximal external rotation allowing releasing the ball while giving height [22]. The speed at release shows WP with lower speed than baseball (16.5 ms^{-1} vs. 33 ms^{-1}) [23, 24], but still, reach the speed of 70 km/h [6]. Any shooting could be blocked, creating additional challenges. For shooters, contact is legal in any moment of the throw, and may cause injuries [10] such as SLAPS or instability. For defenders, due to the blocking position, the shoulder that is in a fully extended forward position is usually moved backwards [6] and may result also in these injuries (Photo 11.4).



Photo 11.3 Player suspended in an eggbeater boost kick while preparing to shoot



Photo 11.4 Defender in a blocking position

Throwing could be a 7-m fast goal shoot or a 20-m precision passing throw [24].

Players have an increased bilateral external rotation usually find in swimmers, and a unilateral decreased internal rotation deficit found in throwers [3, 25]. Internal rotation vs. external rotation ratio strength shows the usual throwers imbalance [26, 27].

This explains abnormalities found in ultrasonography [28] and MRI in virtually any players although only 29% symptomatic [29]. A study performed by Galluccio et al. in 2017 [28] analyzed by ultrasound shoulder injuries in 42 players. This study found only 4 players with no shoulder modifications. When both shoulders were analyzed, the most common bilateral findings were tendinopathy of the supraspinatus (38.10%) and in second place subscapularis tendinopathy (30.95%). Isolated analysis of the throwing shoulder supraspinatus tear (21.43%) and supraspinatus impingement (21.43%) are the

most frequent findings followed by supraspinatus tendinopathy (19.05%).

In MRI, reported alterations are posterior superior labrum, subscapularis tearing, and tendinopathy also in infraspinatus tendons.

Statistics about shoulder injuries are somewhat confusing if we refer to injury reported water polo lesions during FINA WORLD Championships and Olympic Games [7] shoulder injuries were in fourth place (11%). However, this is in a contact acute setting (70%). But if we take injuries as part of a more prolonged time, and not only during competitions, shoulder injuries count up to 51% of total ones in a year period [26] or 24% in a 13-year period, reaching up to 80% in older reports [30].

Wheeler et al. report shoulder “soreness” that is found in all players with a media of 2.9 in a 10-points scale, (explained by the total volume of shooting or less resting during squad selection and team game-based training camps) [31], this not to be counted as an injury report, but is an alarm to be taken to keep players playing.

Prevention should be paramount. However, it is not well defined in what is to be done.

In season shoulder risk is well defined in baseball with less IR and less ER strength in the off season, as a predictor in on season injuries [32, 33] and is one of the key points to see in water polo, but no so well defined [24]. As stated, the volume of shooting and rest intervals could be other. Besides that, overall training efforts concerning swimming, eggbeater kicks [34], core, scapular balance are also areas of interest [22, 24].

11.7 Elbow Injuries

The elbow is a complex joint composed of three bones, the humeroulnar, humeroradial, and proximal radioulnar joint. First two are in charge of flexion and extension of the elbow, and the radioulnar joint is responsible for pronosupination. Joint stability is given by huge bony congruence and its ligament complex. Stabilizers divide into *statics* (articular surfaces, joint capsule, and ligaments) and *dynamics* (biceps muscle, triceps,

anterior brachial, brachioradialis, epicondyles, and epitrochlear muscles) [35].

Elbow injuries are a diagnostic and therapeutic challenge [36]. Its frequency [7] is about 6.6% of total water polo injuries. Most common are overuse injuries, ulnar collateral ligament tear (valgus instability), and osteochondritis dissecans (OCD) [36].

Ulnar collateral ligament lesions can be produced by an acute trauma in goalkeepers, or in blocking ball attempts, or as a result of repetitive microtrauma.

In water polo, the player who is throwing the ball is not standing on a fixed support or firm land; therefore, his upper limb is responsible for generating a big part of the necessary forces to execute the throwing. Moreover, the size of the ball is bigger and heavier than other sports, so this increases elbow stress [30]. The throwing of the ball involves four phases: preparation, cocking, acceleration and follow through. During the cocking and acceleration phases, forces generated in valgus exceed the intrinsic tensile stress of ulnar ligament and may cause repetitive microtears (Photo 11.5). It could result in an unstable medial ligament if these repetitive microtears were not treated adequately. Pain is located on the medial side and can be exacerbated by applying valgus with the elbow in 30° of flexion and the forearm pronated [30].

Dominant extremity repetitive valgus stress might be the main cause to develop an osteochondritis dissecans (OCD). It manifests clinically as pain and edema and mechanic block of the joint [36]. Goalkeepers are likely to suffer OCD after repetitive hyperextension and valgus trauma. An X-ray could show fragmentation with demarcating sclerosis and formation of loose bodies. MRI can detect in more early stages the presence of OCD so it should be part of early screening [37].

Throwing technique is an essential part of the handle and prevention of these injuries as well as the training loads. Flexors and pronator muscles strength should be enhanced and the eccentric action of the biceps must also be improved. Improving the eggbeater efficiency and the timing of the shoot to get a more elevated position of the elbow with respect to the body (90–110° of



Photo 11.5 Valgus requirements of the elbow

abduction) are essential components in the management of this lesion prevention [3].

11.8 Hand and Wrist

Hand and wrist injuries in water polo player have a frequency of 18% [7]. The wrist has a function to put the hand in space to grab the ball.

Most common wrist injury is the acute injury of the triangular fibrocartilage complex of the carpal ligaments that occur when tackling other players or blocking a shot [3]. Clinical presentation is a pain in the ulnar compartment of the carpal bones, audible click in the same compartment, the player can manifest instability when making pronosupination or when distal ulnar epiphysis is prominent. The necessity of making X-ray to dismiss bone injury an MRI or ArthroMRI will define severity and the therapeutic behavior [38].

Repetitive gliding of tendons of the first dorsal compartment (abductor pollicis longus and extensor pollicis brevis) beneath the sheath and over the radial styloid generates de Quervain tenosynovitis [36], as well as the injury of the extensor carpal ulnaris with a similar mechanism. The initial treatment consists of splinting and rest, infiltrations and, if no progress is seen, surgical liberation of the compartment might be indicated (not so frequent in young athletes).

During blocking, catching the ball, or when fingers get caught up in other players swimsuit finger injuries occur. Frequently metacarpophalangeal joint luxation as well as interphalangeal dislocation happens in this situation [12]. They must not only be reduced in place but also evaluated with X-ray to dismiss fracture. They can be splinted by themselves or to the next finger.

In the thumb, the most common lesion is the gamekeeper's thumb; it consists of the ulnar collateral ligament of the metacarpophalangeal joint sprain. It occurs as a cause of the large diameter of the ball and the players attempt to grab it with the hand, opening the fingers as much as they can, so the thumb lies in maximum adduction and is liable to suffer a sprain [30] (Photo 11.6).



Photo 11.6 Grabbing a big ball with thumb in max abduction and fingers fully extended

11.9 Lower Extremity Injuries

Lower extremity injuries can be traumatic injuries or injuries related to the eggbeater kick.

The lower extremity trauma can be produced when tackling other player or trying to recover the position of the ball or while swimming to get the position.

The eggbeater kick is used by water polo players to support their body in an elevated position for extended periods and then raise the body out of the water in an explosive action for defending, tackling, passing, or shooting [3].

It is an extremely complex movement and involves the coordination of both inferior limbs. It combines hip flexion, abduction, and internal rotation plus repetitive hip motion. When it is time to shoot, block or tackle, the player makes a boost action to elevate the trunk and get in position to make the action.

In the knee during the eggbeater, the repeated valgus stress and the loads (during training and matches) can produce medial knee pain. It can generate degenerative changes in the medial side of the knee and pain along or over the origin of insertion of the medial collateral ligament (overuse syndrome) [36].

One of the causes of valgus stress is the reduced range of motion in the abduction and internal rotation of the hip [3]. Therefore, the therapeutic plan not only has to include the knee pain and its study but also a complete reeducation of the eggbeater and full range of motion in the hip.

The hip and groin pain are also a common overuse pain in water polo players. The eggbeater can cause chronic adductor-related groin pain and acute adductor muscle strain. To prevent these injuries, the medical team, as well as the trainers, have to maintain range of motion in the hip and workout the power of the abductor,

core stability, and internal and external rotators of the hip.

The optimization of this movement is a vital aspect of the injury prevention not only in the lower extremities (knee and hip) but also in the elbow and the shoulder because of the position of the body over the water at the time of making sports-specific movements.

Take-Home Messages

- Water polo is a rough collision sport.
- A concussion is a major concern. Its surveillance is of paramount importance.
- Overuse shoulder injuries are common. Internal rotation deficits and IR/ER strength balance are critical to avoid them. Goaling volume needs supervision.
- Eggbeater kick may predispose to the groin and hip pain, also to medial knee pain. Training is essential.
- Medial elbow injuries are common. Elbow mechanics while throwing are key to avoid them.

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