Injuries in underwater rugby: a retrospective cross-sectional epidemiological study

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Key words
Aquatic sports; Breath-hold diving; Diving research; Epidemiology; Gender; Health Survey; Trauma

Abstract
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Introduction: Underwater rugby (UWR) is a team sport which combines swimming sprints, apnoea diving, a good overview of the three-dimensional underwater space and wrestling for the ball.This was the first epidemiological study of UWR injuries in a large international collective.

Methods: A questionnaire containing 124 questions was distributed to 198 active UWR players and completed under the supervision of medical staff. Demographic data and information about injuries in ten different body regions were collected.

Results: Of the 198 respondents, 106 (53.5%) were male and 92 (46.5%) were female. On average, each UWR player suffered a median of 19.5 (IQR 44) injuries. Based on the exposure time, means of 37.7 (SD 90.0) injuries per 1000 playing hours per player and 9.9 (20.1) injuries per year were found. Significant injuries mainly occurred to the head region (45.7%). Bruises and sprains were observed more often than fractures and dislocations. Male athletes had a longer total injury break time (median 4.8 [IQR 10.5] days), than female athletes (4 [8.6] days). Female athletes had more injuries (median 20 [IQR 26.8]) than male athletes (18.5 [63]). The length of the injury-related break time increased with the rise in body mass index.

Conclusions: The risk of severe injury in UWR is low compared to other ball sports like water polo and rugby. UWR is played under water and the impact of tackles is lessened by the water. Further studies should record chronic injuries in UWR and establish measures to prevent injury.

Introduction

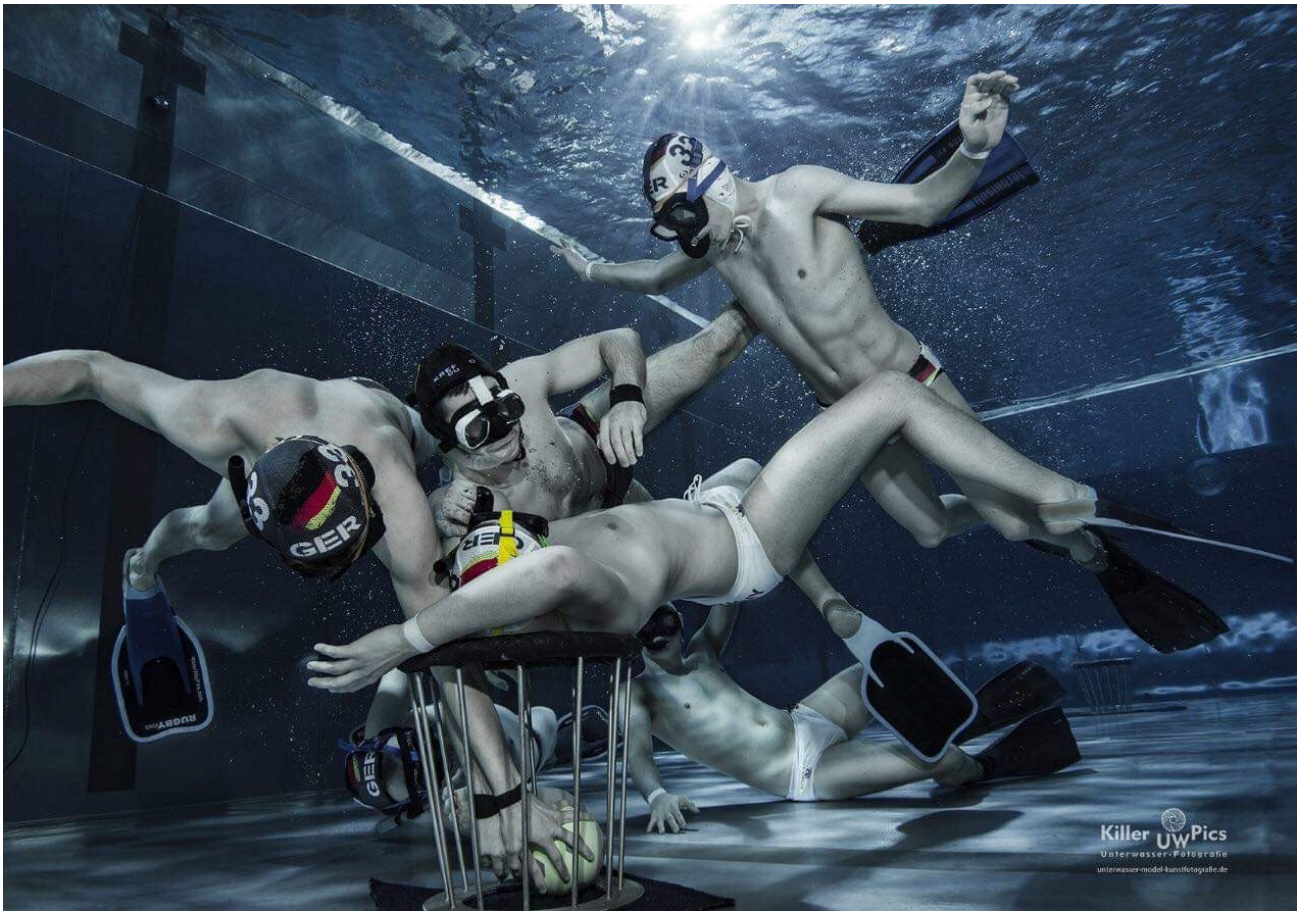
Germany is the birthplace of underwater rugby (UWR) which has been played there since the 1960s. International championships have been held regularly by the Confédération Mondiale des Activités Subaquatiques (CMAS) since the 1970s. There are now national championships in UWR in over 30 countries. World championships with men's and women's teams take place every four years. In addition to the European Championship, there is an annual cup of league winners, the Champions Cup. UWR is a team sport with a maximum of 15 players per team. The game takes place in the three-dimensional playing field of a swimming pool and lasts 30 minutes with two half-times of 15 minutes. To score a goal, the saltwater filled ball must be placed in the opponents' metal basket on the pool floor (Figure 1). UWR requires high endurance, strength and good apnoea training. But tactical sense, maneuverability and speed are also necessary, as correct positioning is crucial for a good passing game. A good overview of the three-dimensional underwater space is essential because members of the opposing team can attack from above or below. Depending on the game situation, the players dive for approximately 15 to 45 seconds in order to intervene again after surfacing to take a few breaths. Every player in possession of the ball may be attacked and may attack other players. Permitted tackles include holding on to arms and legs, scrambling for the ball or pushing the defender away. Attacks on players' equipment (swimwear, head caps with ear protection, diving masks and straps, snorkel and fins) are prohibited. Three referees supervise the game with horn signals that are clearly audible underwater.[1,2] So far, no studies on injury rates and patterns in UWR have been published. The aim of this study was to compile an epidemiological record of UWR-related injuries and overload damage.

Methods

This retrospective cross-sectional epidemiological study was carried out using a questionnaire analogous to previous studies in accordance with the Helsinki Declaration and after review by the responsible ethics committee of the University of Duisburg-Essen (19-9079-BO).[3,4]

The questionnaire with 124 questions was distributed to athletes aged 18 and older and filled in straightaway under

Figure 1
Showing an attack to score a goal during an underwater rugby (UWR) game



the supervision of medical staff who were available to answer questions and explain ambiguities.

Demographic data and information about injuries in ten different body regions (head, trunk, shoulder, elbow, wrist, finger, pelvis/thigh, knee, lower leg/ankle/foot, lungs) were collected. Participants were requested to answer yes/no questions about specific injuries and state the number of injuries sustained. The questionnaire could be answered in German or English. Most of the data was collected during two large competition events, the 10th European UWR Championship (26 June to 01 July 2017 in Helsinki, Finland) and the final of the 16th International Champions Cup (24–26 November 2017 in Berlin). Furthermore, in 2018 some clubs in North Rhine-Westphalia (Germany) were visited during training periods. The exposure time was extrapolated retrospectively from the current weekly training hours over the entire duration of the players' careers. To reduce the recall bias, the downtimes (time out of the game due to injury) were recorded individually according to body region and as total downtime, and then calculated as the average of the two downtimes. Bruises and superficial skin injuries were classified as "*minor*" injuries and distinguished from "*relevant*" injuries.

STATISTICAL ANALYSIS

The statistical evaluation was carried out using IBM SPSS Statistics 25 software (IBM, Armonk, NY, USA). Descriptive statistics included a calculation of means and standard deviations or medians and interquartile ranges where appropriate. All values were tested for normal distribution, with the Kolmogorov-Smirnov test and the Shapiro-Wilk test. The two-sided *t*-test was used for normally distributed values. For non-normally distributed values, the non-parametric Mann-Whitney U test was used to detect differences between unconnected test groups. Values of $P < 0.05$ were considered significant and $P < 0.001$ as highly significant.

Results

PARTICIPANTS

The study included 198 UWR athletes, 106 male (53.5%) and 92 female (46.5%). Within this group, 88.9% played in the Bundesliga or comparable leagues and 73.2% played internationally, while 6.5% played neither internationally nor in the Bundesliga (or comparable leagues). The

Table 1
Characteristics of male and female UWR players; **highly significant differences ($P < 0.001$); BMI – body mass index

Parameter	Males Median (IQR)	Females Median (IQR)
Age (years)**	33 (18)	28 (11)
Height (cm)**	180 (10)	169 (8)
Weight (kg)**	87.0 (18.5)	64 (12)
BMI ($kg \cdot m^{-2}$)**	26.6 (4.6)	22.5 (3.4)
Career duration (years)**	12 (15)	9 (13)
Exposure time (hours)	3,240 (3,780)	2,160 (4,428)
Training scope ($minute \cdot week^{-1}$)	300 (195)	360 (214)

Table 3
Types of injuries reported by the 198 underwater rugby players surveyed. Median injuries per player. As per Table 2, a relatively small number of players experienced large numbers of injuries. IQR – interquartile range

Injury	*n* (%)	Median (IQR)
Bruises	4,946 (52.2)	4.5 (14.0)
Sprains	3,353 (35.4)	4 (13.0)
Ligament ruptures	450 (4.8)	2.3 (7.8)
Fractures	161 (1.7)	0 (1.0)
Dislocations	136 (1.4)	0.7 (4.2)
Overload damage	431 (4.5)	2.2 (7.6)

characteristics of male and female UWR players are shown in Table 1.

INFLUENCE OF SEX ON INJURIES IN UWR

Male UWR players did not show significantly higher values in exposure time compared to female players ($P = 0.207$), but there were highly significant differences in age ($P = 0.001$), height ($P < 0.001$), weight ($P < 0.001$), BMI ($P < 0.001$) and career duration ($P = 0.005$) (Table 1).

The males, with median a total injury break 'downtime' of 4.8 (IQR 10.5) days, had to take longer breaks due to injuries than the female athletes with a median of 4.0 (8.6) days. Male players stated that they had a median of 18.5 (63) total injuries while playing UWR. Female players had a median of 20 (26.8) injuries.

INJURY MECHANISM

The most frequent cause of injury was '*player contact*' (81.8% of injuries), followed by '*injury from an attack*' (42.7%), '*injury from defense against the ball*' (33.9%), '*contact with equipment in general*' (22.9%), '*contact with fins*' (14.6%), '*contact with the ball*' (8.9%), '*out of the water*' (2.6%) and '*injuries caused by warming up*' (1.1%). The most severe injuries were also due to '*player contact*' (71.1%). Note, and injury can have more than one cause, hence these percentages sum to greater than 100%.

Table 2
Injury frequency according to anatomic location; Median injuries per player. A relatively small number of players experienced large numbers of injuries. IQR – interquartile range

Anatomic location	*n* (%)	Median (IQR)
Head injuries	8,082 (45.7)	4 (16)
Trunk	2,449 (13.8)	2 (7)
Shoulder	823 (4.6)	0 (3)
Elbow	1,018 (5.7)	1 (4)
Wrist	524 (3.0)	0 (2)
Finger	3,508 (19.8)	5 (11)
Pelvis and thigh	65 (0.4)	0 (0)
Knee	594 (3.4)	0 (2)
Lower leg/ankle/foot	565 (3.2)	0 (1)
Pulmonary diseases	12 (0.1)	0 (0)
Blackout	61 (0.3)	0 (0)
Total injuries	17,701 (100)	

Table 4
Locations of the 161 fractures reported by the 198 underwater rugby players surveyed

Fracture location	*n* (%)
Finger	47 (29.2)
Ribs	22 (13.7)
Ankle	22 (13.7)
Carpal bones	21 (13.0)
Nose	16 (9.9)
Wrist	12 (7.5)
Elbow	7 (4.4)
Lower leg	6 (3.7)
Mandible	4 (2.5)
Foot	4 (2.5)

INJURY FREQUENCY

A total of 17,701 injuries occurred in 755,569 training hours. Each player suffered a median of 19.5 (IQR 44) injuries. Based on the exposure time, means of 37.7 (SD 90) injuries per 1,000 playing hours per player and 9.9 (20.1) injuries per year were found. Three percent of the respondents ($n = 6$) stated that they had never suffered an injury during UWR. The exact distribution of injuries according to body region is shown in Table 2.

TYPE OF INJURY

The most common types of injury were bruises (52.2%) and sprains (35.4%). Table 3 shows the most common types of

Table 5
Head and finger injuries reported as mean (SD) injuries per player among the 198 players surveyed

Injury type	Mean (SD)
Head injuries	
Abrasions	18.5 (118.3)
Nosebleeds	10.5 (75)
Lacerations	4.4 (37.7)
Lip bites	1.5 (3.6)
Tongue bites	1.4 (5.3)
Concussions	0.4 (1.6)
Eardrum injuries	0.2 (0.6)
Tooth loss	0.2 (0.6)
Nose fractures	0.1 (0.3)
Mandibular fractures	0.02 (0.2)
Cerebral haemorrhage	0.02 (0.1)
Finger injuries	
Finger contusions	13 (48.3)
Finger compressions	4.3 (13.3)
Tendon injuries	1.5 (7.6)
Finger dislocations	0.5 (4.3)
Finger fractures	0.2 (1.5)

injuries. A total of 161 fractures occurred, which are shown in Table 4. Notable injuries were mainly found in the head region followed by finger injuries, which are shown in Table 5. The distribution of fractures of the fingers was as follows: Thumb (digit I) = 14.28%, digit II = 0%, digit III = 28.6%, digit IV = 14.3% and digit V = 42.9%.

INFLUENCE OF BMI

Regarding physical characteristics, 106 (54.5%) players were of normal weight, 66 (33.8%) were overweight, 19 (9.7%) had grade 1 obesity, three (1.5%) had grade 2 obesity and one (0.5%) had a grade 3 obesity according to the BMI classification of the World Health Organisation.[5] Three players did not provide any weight information. The normal weight players had to pause for a median of 4 (IQR 7.8) days due to injuries whereas overweight players had a median of 5 (9) days injury downtime. Among the obese players, the total number of injuries suffered by the individual players decreased the higher their BMI was.

Discussion

To the best of our knowledge, this is the first study to record UWR injuries in a large international player collective. One hundred and ninety-eight active UWR players participated in the study which enabled compilation of a comprehensive overview of this so far insufficiently investigated sport. The limitations of the study are the retrospective design and the inherent recall bias of such investigations. Data such as weight, size, game class, game equipment and training frequency only represent snapshots, so that we did not investigate correlations between game class and injuries. Since only active players were interviewed, serious injuries that resulted in players retiring from the sport may not be adequately recorded. The injury incidences determined are known to depend on the study design and tend to be underestimated in retrospective examinations.[6] It was decided to record all injuries in order to be able to map the sports medicine relevance of UWR more precisely.

INJURY MECHANISM, TYPES AND FREQUENCY

The most frequent injuries in UWR occur through player contact (81.8%) followed by injuries from an attack by an opponent (42.7%). Similar data have been reported in rugby. Here, the most common cause of injury is an opponent's tackle,[7] being responsible for 40% and 48% injuries in two studies.[8,9] Others reported that 80% of all injuries in rugby sport happen during a contact event.[10] These numbers are similar to those in UWR. Water polo is very similar to UWR. It is a team sport which combines swimming sprints and eggbeater kicking, frequent overhead movements and throwing, and regular physical contact. In water polo, player contact is mentioned as one of the most common causes of injury. During the 2004 Olympic Games in Athens, Greece, 56% of the reported injuries in water polo were incurred by contact with another player.[11] The present study also showed that the most common injuries in UWR are caused by player contact, however, foul play was not mentioned as significant. In water polo, most fouls take place underwater, which is difficult for the referee to recognise.[12] In UWR there are three referees who can only concentrate on the underwater scenes. The excessive amount of leg work results in degenerative lower extremity injuries in water polo, which we did not find in UWR. Despite the influence of body contact in water polo, the ball was found to be the second most important risk factor. A third of injuries (33.9%) were caused by defending the ball and 8.9% by contact with the ball.[13,14] Unlike in UWR, which is played underwater without throwing movements, the repeated overhead throwing by water polo players introduces an increased risk for injuries and problems in the shoulder.[15] In the present study, 22.9% of injuries were due to "*contact with equipment in general*" and 14.6% to "*contact with fins*". Other protective equipment, e.g., mouthguards, is not used in UWR, as these would most likely be a hindrance underwater.

The frequency of injuries in water polo is higher than in UWR. There were 37.7 (SD 90) injuries per 1,000 playing hours in the present study compared with 56.2 (6.7) injuries per 1,000 playing hours in water polo.[16] This may be due to the fact that in the study in water polo players took place mainly under competition conditions.[16]

The most significant injuries in UWR were found in the regions of the head and fingers. The most common water polo injuries were laceration (12.7%) and contusion (10.9%) of the head, followed by (sub-) luxation/sprain of the hand (9.5%) and contusion of the trunk (6.5%) or hand (6.2 %).[16] These results correspond to those that we recorded for UWR. We did not find any accumulation of hamate fractures in

UWR, as described in a prior case series in UWR.[17] The majority of water polo injuries observed during the last three FINA World Championships occurred during competition with 10% to 23% of surveyed athletes reporting injuries.[18] This has not yet been sufficiently investigated for UWR. One study highlighted a higher risk of finger injuries in American football and rugby than in other sports. Contact with the ball was given as the reason.[19] Differences with other injury prone sports is probably related to the fact that UWR is played underwater and although it is a hard contact sport, the impact of contacts/tackles and movements is absorbed and lessened by the water.

In the present study, 2,290 weeks of break time from play were lost due to injuries in UWR. This is an average total break time per player of 11.6 weeks. This is a longer injury duration than is reported for example in rugby at 7.6 weeks per player.[20] Our study showed a total of 17,701 injuries in 755,569 training hours. The UWR players interviewed had suffered a median 19.5 (IQR 44) injuries. This is a high number and underlines how physical and risky UWR is for the player. In terrestrial rugby, the frequency of injuries is lower. When normalised to exposure time, the present UWR study showed an average of 37.7 (SD 90) injuries per 1,000 hours of play or 9.9 (20.1) injuries per player per year. In a study of 803 amateur and professional rugby players who completed an average of 21.9 matches per player the injury frequency was 16.4 (14.8 to 18.1) per 1,000 playing hours.[9]

INFLUENCE OF SEX AND BMI ON INJURIES

The female UWR players in our survey sustained more injuries than male UWR players. One explanation could be that male UWR players have more strength and are probably more athletic than female players. On the other hand, male players had to take longer breaks due to injuries than the female players in our study. One reason for this could be a higher injury severity in male players. Further possible reasons should be established in follow-up studies. Current studies of other sports also show gender-specific differences with regard to injuries. The National Collegiate Athletic Association (NCAA) recorded all injuries for men's and women's swimming and diving teams over five years. Interestingly, female swimmers had a 58% higher rate of overuse injuries compared with male swimmers.[21] In contrast to UWR, most injuries were caused by overwork and did not affect the head but the shoulder.[22] However, it depends on the sport itself whether female or male athletes are affected more often, and which body region is injured more often.[23,24]

Over half of all the UWR players surveyed were of normal weight (54.5%). In this study, the number of days off due to injury increased with the rise in BMI. Obese UWR players showed the highest number of total injuries. This group was followed by the normal-weight players. In the group of obese UWR players, the total number of injuries sustained by individual players decreased the higher the BMI was. In contrast to these results, other studies on various sports have observed a correlation between susceptibility to injury and increasing BMI.[25,26] The results of this study could be explained by the underwater playing environment. The actions of UWR players with a higher BMI are supposedly slower, so that less force arises in collisions.

Conclusions

This is the first epidemiological survey of injuries in UWR that the authors are aware of. The analysis shows a predominance of injuries in the head region followed by injuries to the fingers and minor musculoskeletal injuries. Despite sometimes fierce physical contact, the risk of injury is low compared to some other ball sports. Injuries to the lower extremities are particularly infrequent. The reasons for this are, on the one hand, the three-dimensional playing field and the cushioning effect of the water and on the other, the strict rules of the game and the intensive referee policing of these rules. In summary, the injury mechanism and the type of injury in UWR are comparable to other similar sports, such as rugby football, water polo or other water sports. It will be interesting in following studies to record chronic injuries in UWR. Further studies are necessary to produce an overall assessment of this sport and establish measures to prevent injury.

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