Epidemiology Of Acute and Overuse Injuries in Underwater Rugby.

ABSTRACT

Background: Underwater rugby (UWR) is an invasive team sport. Athletes require a high degree of strength, endurance, speed and coordination. Intense physical contacts are an inherent within the sport and may result in injury. Currently, a paucity of literature exists regarding injury occurrence in UWR.

Hypothesis/Purpose: To examine the nature and prevalence of acute and overuse injuries in UWR.

Study design: Descriptive Epidemiology Study.

Methods: Between 11/2020 and 03/2021, German UWR athletes were invited to take an online survey developed by orthopaedic specialists together with UWR athletes. Data were recorded regarding general and health-related data, training habits as well as acute injuries that necessitated an interruption in training and/or doctor consultation as well as overuse injuries. Overuse injuries were evaluated using the Oslo Sports Trauma Research Centre (OSTRC) Overuse Injury Questionnaire.

Results: A total of 161 active athletes (36.1 ± 11.9 years old, 75.3% male), of which 90.1% were competing regularly. The performance level distribution was: 1st German national league: 73x, 2nd German national league: 46x, state league: 17x, district league: 1x, no league: 24x. The mean sport-specific training workload was 5.6 hours per week, including UWR training, additional swimming (n = 71, 44.1%), strength (n = 70, 43.5%) and/or endurance training (n = 102, 63.4%). Acute injuries were recorded in 78.8% of all athletes. The most typical locations for acute injuries were: hand/finger (42.2%), head/face (concussion, ruptured eardrum; 18.1%), wrist (5.5%) or cervical spine (5.0%). Overuse injuries were reported by 42.8% of the participants. The predominant locations for overuse inuries were: hand/finger (18.8%), shoulder/clavicle (14.1%), cervical spine and wrist (10.7% each), head/face (8.7%), ankle joint and knee (6.7% each).

Conclusion: The present study on athletes of different performance levels analyzes the distribution of injuries in UWR, with 3 out of 4 athletes reporting at least one acute injury and 2 out of 5 athletes reporting at least one overuse injury. Leading injury regions are hand/finger injuries, head/ear injuries, wrist and cervical spine injuries. The knowledge gained can help to establish prevention concepts in the future.

Key Terms: Prevention, diving, rugby, hamate, sports injury

What is known about the subject: Limited data is available on injuries in Underwater rugby. However, hamate hook injuries seem to be a typical type of injury within the sport.

What this study adds to existing knowledge: Common acute injuries within the sport are hand/finger or head/ear injuries. Overuse injuries predominantly affect the hand/finger or shoulder/clavicle.

INTRODUCTION

Underwater rugby (UWR) is a team sport that originated in Germany in the 1960s and has since spread worldwide. It is currently practiced in over 30 countries. International tournaments are regularly held and since 1980 the World Championships have taken place every 4 years. The sport is governed by the Confédération Mondiale des Activités Subaquatique (CMAS) who organize international tournaments. The Verband Deutscher Sporttaucher e.V. (VDST) in Germany is - with 79 UWR-clubs registered - the world's largest national federation for the sport. There are first and second national leagues (Bundesliga) as well as further state and district leagues. Most teams thereby compete with a mixed (male/female) team. In addition, there is an all-women's league on first league-level. A UWR team consists of 6 players (as well as 6 change players and 3 reserve players). The changes take place on the fly via a substitution lane at the edge of the field. The playing field is 12-22m long, 8-12m wide and 3.5-5m deep, depending on the pool in which the game is played in. The ball, which may only be played underwater, is filled with salt water so that it sinks in the pool. It has the shape and size of a handball. Players wear fins, diving masks and snorkels. The goal of the game is to place the ball in the opponent's basket. These baskets are located at the edges of the playing field and are attached to the bottom of the pool. [5,11,19,24]

The game requires a high degree of strength, endurance, speed and coordination. Intensive physical contact is inherent within the sport and may result in injury. Injury data in related water sports exists, e.g., water polo (Croteau et al. [6], Franic et al. [10]) and swimming (Wanivenhaus et al [25], Hill et al. [12]). Publications exist in regarding a generally high injury prevalence (Meyer, 2021, Diving Hyperb Med) as well as regarding specific injuries incurred in UWR for example hamate fractures of the ball-carrying hand [1,13,20] and an increased incidence of back pain [9]. Atilla et al. [2] characterized injuries of master swimmers by using a questionnaire for athletes. This method appeared useful to provide an overview of injuries in a sport and was used as such in this study of UWR. A paucity of information relating to the general epidemiology of injury in UWR exists.

The aim of the present study was therefore to examine the nature and prevalence of injury in a cohort of UWR athletes.

MATERIALS AND METHODS

Design and study population

This study is a cross-sectional retrospective survey. A web-based questionnaire was designed by four of the authors (**,**,**,**) to assess common injury patterns and mechanisms of injury among active German UWR athletes. Pilot testing of the survey was performed by the fourteen members of the German national team. No financial compensation was provided in exchange for participation.

Survey

Institutional ethics approval was obtained for the study (*****) and the participants gave written informed consent. The online platform SurveyMonkey® (SurveyMonkey, San Mateo – CA, United States) was used to prepare the survey. Invitations to participate were emailed to 48 sports clubs across 5 leagues within Germany. The survey (online from November 25th 2020 until March 15th 2021) included 32 to 111 questions depending on the number of reported injuries, covering various aspects regarding sports activity in both training and competition and UWR-related injuries.

A minimum number of completed answers was waived as the study was opportunistic in terms of sample size and not driven by statistical testing.

First, general and health-related data on age, gender, body size, pre-existing conditions and, if applicable, medication of the participants were collected (n = 10 questions). This was followed by UWR-related questions (n = 14) on training load, experience, playing position, and performance level. The third section collected information on chronic overuse injuries of the sport (n = 9 questions). For the localization of the overuse injuries, the classification according to OSICS 10 Orchard Sports Injury Classification System (OCICS 10) was used. Multiple entries were possible. To assess the severity of chronic complaints, a score was calculated from the four questions of the Oslo Trauma Research Centre (OSTRC) Overuse injury Questionnaire. These were previously translated into German. A minimum of 0 and a maximum of 25 points could be assigned to each question. After adding up the points, the score for each respondent ranged from 0 to 100 points, with 0 representing no complaints and 100 representing the maximum level of complaints. In addition, information was provided on the characteristics of the complaints, the period during which they existed and what therapy they received.

The fourth and last section dealt with acute injuries. Up to four different acute injuries could be specified individually, for each of which the same questions were asked (n = 18 questions). These included type, circumstances, and consequences of the injuries and to what extent they

were treated medically. Lastly, questions were asked about minor injuries that did not result in a break from training or medical treatment. In total, the questionnaire had a minimum of 32 and a maximum of 111 questions, depending on the number of injuries and overuse injuries that were reported.

Statistical Analysis

Survey data was exported from SurveyMonkey to Microsoft Excel (Microsoft, Redmond, WA); statistical analyses were performed using SigmaStat software (Systat Software Inc., San Jose, CA). Values were checked for normality with the Shapiro-Wilk test. To determine the difference between groups, a t test or rank-sum test was used, depending on normal distribution. A nonparametric Kruskal-Wallis 1-way analysis of variance on ranks was used for non-normally distributed data among several groups. For further specification of groups, correlation analysis and multiple comparisons were performed. Data are expressed as mean ± SD (range). Subgroup analyses were made for athletes of different performance levels as described. P-values < 0.05 were considered statistically significant.

RESULTS

Study population

A total of 161 athletes responded to the survey. The average time needed to answer all questions was 14 minutes. Among the 161 athletes surveyed, 119 were men and 39 were women (3 times no gender information was given). The gender ratio of M:F was thus approximately 3:1. The average age of the respondents at the time of the survey was 36.1 ± 11.9 (17-67) years. Further details on the study population are given in Table 1.

On average, the respondents practiced UWR for 14.9 ± 10.8 (2–45) years. Most athletes stated to train in a gender-mixed team set-up (96.3% [n=155]). The remaining 3.7% (n=6) of respondents trained in an all-male team/~~an~~ all male-teams. Participants in women-exclusive or youth teams were not represented in the survey. In terms of warming up during UWR training, 77% (n=124) reported doing so during swim-in, 10% (n=16) warmed up before entering the water, and 13% (n=21) reported not warming up at all.

The three playing positions (goal, defense, forward) were evenly distributed among the athletes: 58 reported playing defense, 54 goalkeeper and 48 forward (1 no answer). Playing position did not influence the type of injury.

137 of the 161 participants played in a league in Germany at the time of the survey (see Figure 1) and all but 16 participants play regularly in tournaments. The study included 29 national team athletes.

Table 1 Demographics, Training and Performance level of all participants and grouped performance level

	All participants	***National team athletes***	***Non-national team athletes***	***P Value***
Number	161	29	132	
Demographic data:				
Age (years)	36.1 ± 11.9 (17-67)	30.3 ± 9.8 (17-58)	37.4 ± 12.0 (17-67)	.003
Gender (m:f)	119:39	22:7	96:32	
Height (cm)	180.1 ± 8.4 (158-202)	180.5 ± 8,7 (168-202)	180,0 ± 8,4 (158-200)	NS
Weight (kg)	82.7 ± 14.0 (50-120)	85.6 ± 13.7 (63-120)	82.0 ± 14.0 (50-115)	NS
BMI	25.4 ± 3.4 (18.9-38.1)	26.2 ± 3.1 (21.6-33.2)	25.2 ± 3.4 (18.9-38,1)	NS
Training:				
Years of training	14.9 ± 10.8 (2-45)	12.1 ± 6.4 (2-28)	15.5 ± 11.4 (2-45)	NS
UWR training (h/week)	2.6 ± 1.1 (1-7)	3.3 ± 1.3 (1-7)	2.4 ± 1.0 (1-5)	<.001
Swimming training yes:no	71:90	14:15	57:75	
Swimming training (h/week)	0.7 ± 0.9 (0-4)	0.7 ± 1.1 (0-4)	0.6 ± 0.9 (0-4)	NS
Strength training yes:no	70:90	18:11	52:79	
Strength training (h/Woche)	1.0 ± 1.5 (0-8)	1.6 ± 1.7 (0-6)	0.9 ± 1.4 (0-8)	.015
Endurance training yes:no	102:58	19:10	83:48	
Endurance training (h/week)	1.4 ± 1.9 (0-15)	1.4 ± 1.6 (0-5)	1.4 ± 1.9 (0-15)	NS
Total training (including UWR, swimming, strength, endurance)	5.6 ± 3.0 (1-18)	7.0 ± 3.6 (1-15.5)	5.3 ± 2.8 (1-18)	.005
Other sports (h/week)	1.7 ± 2.4 (0-15)	0.9 ± 1.3 (0-4)	1.8 ± 2.5 (0-15)	NS
Overall training (h/week)	7.1 ± 4.5 (1-33)	7.8 ± 4.2 (1-18,5)	7.0 ± 4.5 (1-33)	NS
Tournaments				
Tournaments per year	2.6 ± 2.0 (-15)	4.0 ± 2.9 (1-15)	2.3 ± 1.6 (0-8)	.001

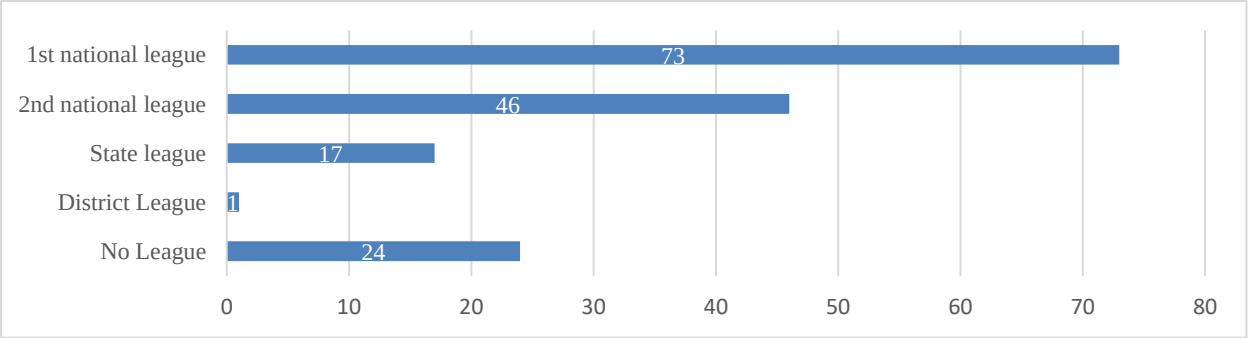

Figure 1 League participation

The training workload averaged 2.6 ± 1.1 (1-7) hours of UWR per week, with high-level athletes practicing significantly more. Further details are given in Table 1. Overall, participants reported a total of 7.1 ± 4.5 (1-33) hours of sports per week. Including swimming-, strength and endurance training (but not other sports), national team athletes had a training workload of 7.0 ± 3.6 (1-15.5) hours per week, whereas non-national team athletes had a training workload of 5.3 ± 2.8 (1-18) hours per week. National team athletes were significantly younger and competed significantly more often than the comparison group, but did not differ in height, weight, and BMI from the other players (see Table 1).

Acute injuries

A total number of 238 independent acute injuries were reported in 127 athletes. On average, 1.5 ±1.1 injuries were reported per athlete (for further details see Figure 2). The majority (152 injuries) occurred during training, considerably less (n=61) occurred in tournaments. The upper extremity was most frequently affected by acute injuries (58%, 138 injuries), followed by the head/neck area (23%, 55 injuries). The lower extremity accounted for a much smaller proportion (7%, 17 injuries), and the trunk (4%, 10 cases) was also rarely affected (see Figure 3 for exact distribution of injuries). The eight most common injury regions in terms of injury type and typical injury mechanisms are explained below.

The most frequent injuries occurred to the hand, finger, and thumb. These were primarily capsular tears, followed by contusions/sprains and fractures (for more details see Figure 4). The players were more often in possession of the ball and most of the injuries occurred while fighting for the ball. When this was not the case, it was usually hits by opponents' fins that resulted in finger or thumb injuries.

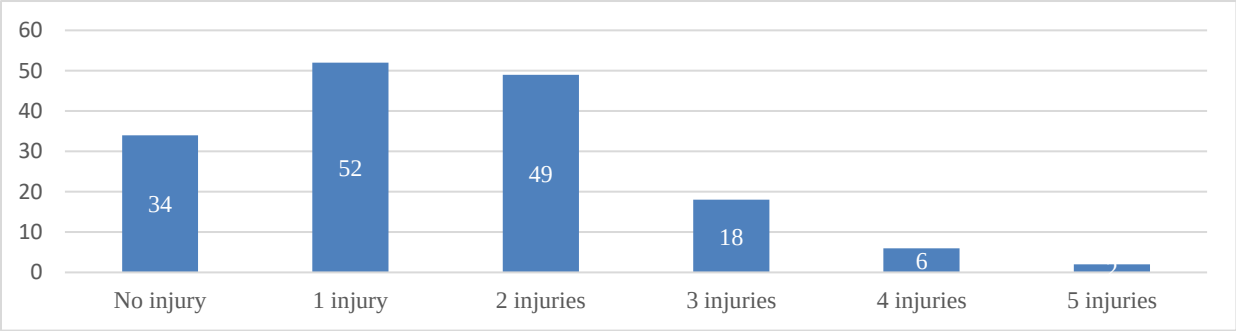

Figure 2 Total number of sustained acute injuries per person during career

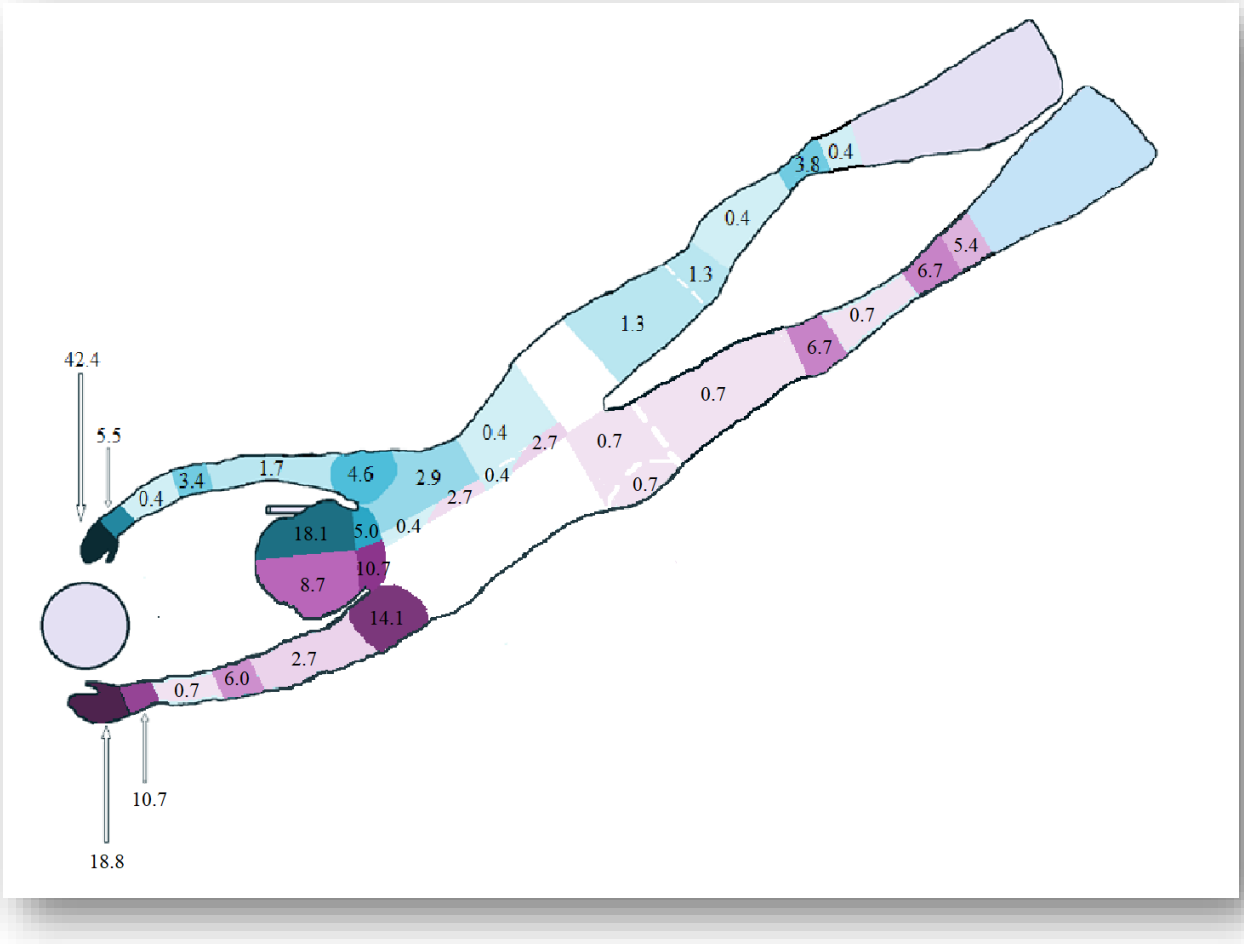

Figure 3 Distribution of acute (blue) and chronic injuries (purple) in percent each

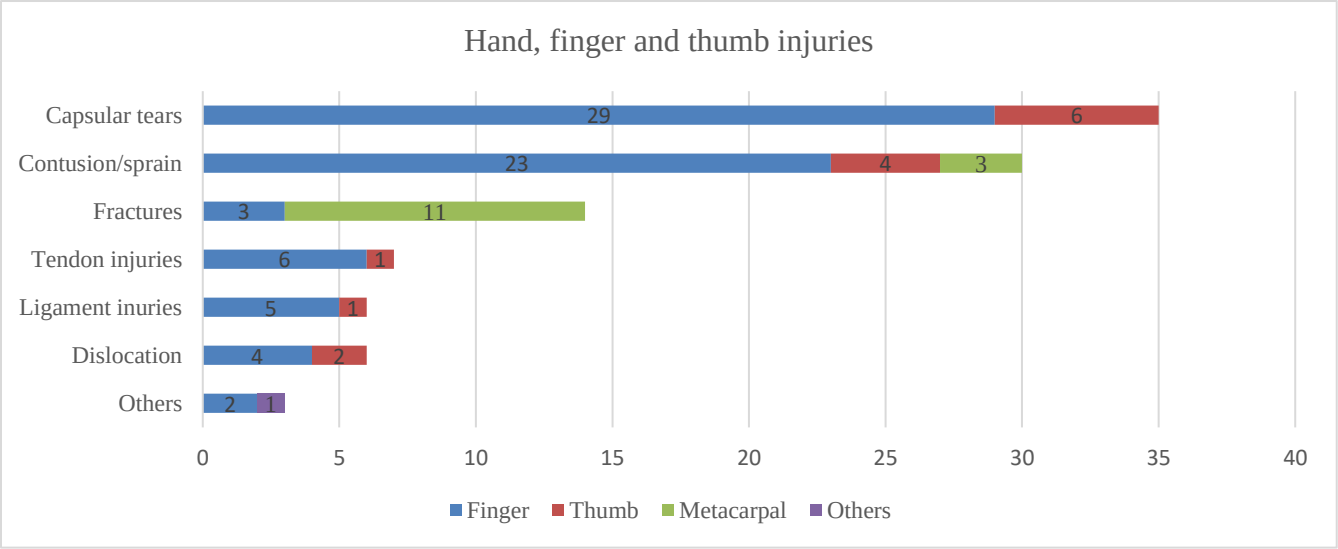

Figure 4 Types of acute injuries of hand/fingers/thumb

Head/face injuries were the second most common entity and affected the ears in about 50% of cases. Mostly they were ruptured ear drums, caused by blows on the ears (e.g., by fins). Concussions, cuts or lacerations were also frequent (see Table 2). Those injuries mostly occurred during duels, except for six concussions and one laceration where the affected individuals had no contact with the opponent. Instead, the cause of injury was swimming with the head against a wall of the pool or against the basket.

Wrist injuries came third in the survey and the most common entity was a fracture of the hamatum bone (see Table 2). The cause of injury is known in ten cases. In the majority (n=7), there was direct opponent contact and a blow to the wrist occurred either in the struggle for the ball or by the opponent's foot or fin. In the remaining three cases, bumping the hand at the basket caused a fracture of the hamatum bone.

Injuries of the neck/cervical spine were documented with approximately the same frequency as wrist injuries. Most frequently, these were distorsions (for more see Table 2). Contact with an opponent was present in all those injuries. Shoulder injuries included dislocations, sprains, and others (see Table 2). A consistent mechanism of injury could not be found. The majority of injuries that affeted the ankle were capsular or ligament tears (see Table 2). Eight of the nine injuries resulted from direct force applied to the fin or ankle by an opponent. Elbow injuries included biceps tendon tears and joint irritation attributed to violent bruising of the elbow on the pool wall. Injuries to the ribs (fractures and contusions) were reported and mostly caused by kicks from opponents (Table 2).

Table 2 Types of acute injuries concerning haed/face, wrist, neck/cervical spine, shoulder, ankle, elbow and ribs/chest

Injury Localization	***Types of injury***	***Number***
Haed/face	Ear:	
	Ear drum perforation	15
	Hearing loss	2
	Inner ear disorder	2
	Others	2
	Concussions	11
	Cuts/lacerations	9
	Others	2
Wrist	Hamate Fractures	7
	Fracture (unkown bone)	1
	Contusion/sprain	2
	Others	3
Neck/cervical spine	Distorsion	7
	Herniated disc	2
	Strain of neck muscles	2
	Laryngeal fracture	1
Shoulder	Dislocation	3
	Sprain	3
	Labrum lesion	2
	Others	3
Ankle	Capsular-/ligamental tear	5
	Distorsion	2
	Others	2
Elbow	Distal biceps tendon rupture	2
	Irritaion of the joint (including bursitis and epicondylitis)	4
	Others	2
Ribs/Chest	Rib fractures	4
	Rib contusion	2
	Other	1

For further injury circumstances see Table 3. In part, statistically significant differences can be seen between the localizations regarding the circumstances surrounding the injury. It was significant, that in possession of the ball, the wrist was more likely to be affected by injuries, compared to injuries to the head. While attacking the opponent`s basket the number of wrist injuries was also significantly greater compared to those that affected the head.

Table 3 Injury circumstances and injury consequences of common acute injuries. Superscripts indicate injury localizations that are significantly different from each other at the 0.05 level.

	All	***Hand/ Finger/ Thumb***	***Head/ Face***	***Wrist***	***Neck/ cervicale spine***	***shoulder/ clavicle***	***Ankle***	***Ellbow***	***Ribs/ Chest***	***P Value***
Number	238	101	43	13	12	11	9	8	7	
Injury circumstances:										
Training:Tornament	152:61	69:25	29:13	8:4	9:3	6:3	7:2	5:2	4:3	NS
Ball posession yes:no	113:96	60:36	14:26[a]	10:1[a,b]	2:10[b]	4:4	4:5	5:1	3:4	.001
Complaint start Immediatly:gradual	183:28	88:6[a]	36:5	12:0	9:3	7:1	7:2	4:3[a]	6:1	.044
Injury location on the court										
Middle of the pool	71	41	11	2	4	2	4	1	3	
Attack on opponent`s basket	49	27	7[a]	9[a, b]	1	0[b]	4	1	0	
Defending own basket	40	14	9	0	3	2	0	2	2	
Water surface	22	5	5	0	3	2	1	1	1	
Bottom oft he pool	12	3	4	0	0	1	0	1	1	
Penalty (striker)	1	1	0	0	0	0	0	0	0	
Penalty (goal keeper)	1	0	0	0	1	0	0	0	0	
unknown	42	10	7	2	0	4	0	2	0	.01
Training interruption:										
yes:no	190:27	82:16	37:5	12:0	11:1	7:2	9:0	7:0	7:0	NS
weeks	5.3 ± 7.1 (0-60)	3.5 ± 4.3 (0-24)	6.2 ± 10.6 (0-60)	10.2 ± 4.2 (4-20)	6.5 ± 6.6 (0-20)	6.0 ± 5.4 (0-12)	6.0 ± 1.3 (4-16)	11.6 ± 16.3 (1-40)	4.1 ± 2.9 (1-10)	<.001
Work stoppage										
yes:no	26:189	8:88	6:36	1:11	3:9	1:8	2:7	2:5	1:6	NS
weeks	0.3 ± 1.4 (0-12)	0.2 ± 0.8 (0-6)	0.2 ± 0.6 (0-3)	0.04 ± 0.1 (0-0.5)	0.2 ± 0.4 (0-1)	1.3 ± 4.0 (0-12)	0.2 ± 0.4 (0-1)	2.0 ± 3.5 (0-8)	0.1 ± 0.4 (0-1)	NS
Doctor`s contact										
yes:no	153:63	55:42[a]	36:6[a]	11:1	11:1	7:2	6:3	7:0	4:3	.002
Diagnostics										
physical examination	123	39[a]	32[a, b, c, d, e]	9[b]	10[c]	6[d]	6	6[e]	2	
x-ray	80	43[a]	1[a, b]	9	7[b]	5	3	4	2	
MRT	29	6	2	7	3	4	1	2	0	
CT	12	1[a]	1	8[a]	0	1	0	1	0	
Sonography	13	3	0	1	0	2	0	1	1	<.001
Hospitalization										
yes:no	15:196	1:93[a, b]	3:38	3:9[a]	1:11	1:8	0:9	2:5[b]	0:7	.005

days	0.3 ± 1,3 (0-10)	k.A.	0.3 ± 1.4 (0-8)	0.5 ± 1.2 (0-4)	0.4 ± 1.4 (0-5)	0.2 ± 0.7 (0-2)	-	1.9 ± 3.8 (0-10)	-	.001
Operation										
yes:no	25:189	5:91[a, b]	5:37	4:8[a]	1:11	3:6	0:8	3:4[b]	0:7	.001
Immobilization										
yes:no	83:126	52:41[a]	0:41[a, b, c, d, e]	4:8[b]	2:10	4:5[c]	4:4[d]	4:3[e]	1:5	<.001
weeks	2.0 ± 4.7 (0-52)	2.3 ± 3.2 (0-16)	-	9.1 ± 15.4 (0-52)	0.1 ± 0.3 (0-1)	2.7 ± 3.7 (0-10)	1.6 ± 2,3 (0-6)	2.0 ± 2,8 (0-6)	0.2 ± 0.4 (0-1)	<.001
Physiotherapy:										
yes:no	33:181	10:86[a]	1:41[b, c, d]	3:9	5:7[b]	5:4[a, c]	1:7	3:4[d]	0:7	<.001
weeks	1.2 ± 3.5 (0-20)	0.6 ± 1.8 (0-10)	0.1 ± 0.6 (0-4)	1.8 ± 4.0 (0-12)	4.1 ± 5.4 (0-14)	5.9 ± 7.8 (0-20)	0.5 ± 1.4 (0-4)	6.3 ± 9.0 (0-20)	-	<.001
Rehabilitation										
yes:no	3:206	1:92	0:41	0:12	0:12	0:9	0:8	0:7	0:7	NS
Permanent damage										
yes:no	47:167	23:72	5:37	3:9	5:7	3:6	0:9	3:4	0:7	NS

The most common hand/finger/thumb injuries resulted in the shortest training interruption, averaging 3.5 weeks. In contrast, wrist or elbow injuries were less common but had a significantly longer rest period, averaging 10.2 and 11.6 weeks, respectively. In case of hand/finger/thumb injuries hospitalization and surgical therapy were significantly less frequent, in contrast to wrist and elbow injuries.

When comparing national and non-national team athletes, no differences were found in the frequencies, consequences, and circumstances of acute injuries, with one exception. Specifically, the proportion of injuries that occurred in competition was greater among national team athletes (see Table 5).

A comparison between first league players (n=78) and all other study participants (n=88) showed a higher rate of acute injuries in the first league. Those players also had consulted doctors more frequently after injuries (see Table 6).

Overuse injuries

A total number of 149 independent overuse injuries were reported in 69 athletes. Most affected athletes reported complaints in one to two body regions. More than half of the complaints (53% or 79 statements) involved the upper extremity (for detailed information see Figure 3). The hand, fingers and thumb were most frequently affected. Complaints were attributed by the athletes to recurrent overextending, sprains and bruises, which occurred in duels and sometimes also resulted in slight capsule tears. Tapes to stabilize the finger joints were mostly used as a measure against this. Shoulder pain (second-most mentioned) was frequently reported after long days of play or strenuous training. Targeted strengthening and stability exercises were mentioned as the most common remedy against it. In third place were overuse injuries of the wrist, as well as the cervical spine. Neck pain were caused by frequent overstretching, strains and sprains and were treated by many athletes with physiotherapy and stretching. Wrist pain was mostly load-related and attributed to repetitive “minor” sprains or past traumatic events. Less than half of affected athletes stated that they used tapes and braces to stabilize the wrist. Chronic complaints in the area of the head primarily concerned the ears (inflammations, hearing loss, feeling of pressure), and headaches. The affected athletes related these partly to strenuous training while frequently needing to hold their breaths, and as a result of problems with the paranasal sinuses due to equalizing pressure. The cause of pain in the ankle joint was seen by the athletes as the load on the joints caused by the fins. The overload reactions of knees and elbows were described unspecific.

On average, the complaints had existed for 6.6 ± 6.5 (0.5-33) years. No significant differences could be identified between the duration of complaints of the eight most frequent localizations (see Table 4).

For the total of 161 participants in the survey, a mean OSTRC severity score of 13.2 ± 19.4 (0-75) resulted, and for the 69 respondents who reported at least one chronic complaint symptom, the mean score was 21.5 ± 21.2 (0-75). The OSTRC severity score did not differ significantly between the different localizations of the complaints (see Table 4).

In the comparison of athletes with different performance levels no differences could be found regarding chronic injuries (see Table 5 and 6).

Table 4 Number, complaint period, and OSTRC severity score of common chronic injuries.

	All	***Hand/ Finger/ Thumb***	***shoulder/ clavicle***	***Wrist***	***Neck/ cervicale spine***	***Head/ Face***	***Ankle***	***Knee***	***Ellbow***	***P Value***
Number	149	28	21	16	16	13	10	10	9	
Complain period (years)	6.6 ± 6.5 (0.5-33)	7.3 ± 7.6 (1-28)	5.0 ± 6.1 (0.5-28)	5.2 ± 3.8 (1-11)	9,0 ± 8,8 (1-28)	10,25 ± 10,2 (1-33)	5,3 ± 3,8 (1,5-10)	11,2 ± 9,2 (1-28)	5,6 ± 4,7 (1-13)	NS
Complain period (in % related to training age)	49.0 ± 30.9 (2.6-100)	47,.0 ± 33.0 (3.8-100)	41.0 ± 31.3 (2.6-100)	50.9 ± 31.8 (5.9-100)	41.3 ± 31.9 (3.8-100)	71.1 ± 28.0 (15-100)	46.0 ± 19.4 (18.8-75)	63.9 ± 23.8 (33.3-100)	49.5 ± 38.3 (12.5-100)	NS
OSTRC severity score	21.5 ± 21.2 (0-75)	21,8 ± 21,1 (0-75)	27,5 ± 20,0 (0-75)	20,4 ± 15,2 (0-44)	33,3 ± 27,9 (0-75)	21,8 ± 27,6 (0-75)	28,0 ± 27,9 (0-75)	26,6 ± 17,0 (8-66)	19,1 ± 22,4 (0-63)	NS

Table 5 Comparison of acute and overuse injuries between national- and non-national team athletes

	National team athletes	***Non-national team athletes***	***P Value***
Number	29	132	
Acute injuries:			
Number	53	185	
Per person	1.8 ± 1.2 (0-4)	1.4 ± 1.1 (0-5)	NS
Training:Tournament	29:20	123:41	.032
Doctor`s contact (yes:no)	37:13	116:50	NS
Training interruption (weeks)	5.8 ± 6.9 (0-30)	5.2 ±7.2 (0-60)	NS
Work stoppage	0.03 ± 0.2 (0-1)	0.4 ± 1.6 (0-12)	NS
Chronic injuries:			
Number	35	114	
Per person	1,2 ± 1,6 (0-5)	0,9 ± 1,4 (0-11)	NS
Complain period (years)	1,9 ± 2,6 (0-10)	2,8 ± 5,6 (0-33)	NS
Complain period (in % related to training age)	17,9 ± 25,0 (0-82,1)	20,3 ± 32,2 (0-100)	NS
OSTRC severity score	14,3 ± 19,4 (0-63)	12,9 ± 19,5 (0-75)	NS

Table 6 Comparison of acute and overuse injuries between first league- and not first league athletes

	First league athletes	***Other athletes***	***P Value***
Number	73	88	
Acute injuries:			
Number	124	114	
Per person	1,7 ± 1,0 (0-4)	1,3 ± 1,2 (0-5)	0,012
Training:Tournament	80:30	72:31	NS
Doctor`s contact (yes:no)	73:40	80:23	0,05
Training interruption (weeks)	5,2 ± 5,9 (0-30)	5,5 ± 8,3 (0-60)	NS
Work stoppage	0,2 ± 1,3 (0-12)	0,4 ± 1,5 (0-10)	NS
Chronic injuries:			
Number	75	74	
Per person	1,0 ± 1,4 (0-5)	0,9 ± 1,6 (0-11)	NS
Complain period (years)	3,0 ± 5,3 (0-28)	2,4 ± 5,3 (0-33)	NS
Complain period (in % related to training age)	18,9 ± 29,5 (0-100)	20,7 ± 32,4 (0-100)	NS
OSTRC severity score	13,9 ± 19,8 (0-75)	12,4 ± 19,2 (0-75)	NS

DISCUSSION

The most important finding of the presented study is that significantly more acute than chronic injuries were recorded, mainly involving the upper extremity (58% of all acute injuries), especially the hands. Compared to other injury localizations, hand/finger/thumb injuries were the least severe. Wrist injuries were much less frequent but more severe. These injuries occurred predominantly while the player was in possession of the ball and attacking the opponent's basket. Futhermore, head injuries (18.1% of all acute injuries) were found to predominantly occur during defense and without possession of the ball. Additionally, overuse injuries in UWR were found to be of minor severity. The upper extremity (53% of all chronic injuries), primarily hand and shoulder were primarily affected. Finally, acute injuries were more common in the head, hands, and thorax, while cervical spine, shoulder, knee, and feet were more prone to chronic overuse injuries.

The severity of all chronic injuries in UWR in this study was averaged 21.5 points according to the OSTRC severity score. This is roughly in the same range as the severity of overuse injuries in ice hockey where scores between 16.8 and 33.4 can be found [4,17,18]. Delfino Barboza et al. showed a severity of 21 points in the score among field hockey athletes which is comparable with the present study. [7]

The knowledge gained can help to establish prevention concepts in the future. Regarding the most common injury regions found in the study, these could be, for example, training programs for finger and wrist stabilization, prohibition of reaching into the opponent's fingers or tightening of rules regarding head/neck contact.

Several publications focusing on water polo found acute injuries mainly in the area of the head and face as well as the hands, while overuse injuries were found predominantly around the shoulders. [6,10,16,22,23,26] In their recent meta-analysis, Croteau et al. found head injuries to be the most common acute injuries in water polo (period prevalence of 20.5-53%). [6] In our study, head injuries represented the second most frequent localization of injury in UWR (18.1% of all acute injuries). Primary injury types in water polo were described to be contusions, concussions, cuts and fractures, and injuries to the teeth, eyes, and ears. Ear injuries thereby have the greatest similarity to UWR injuries, as found in our study. In both sports ear drum ruptures represented the leading type of injury. Protective caps are nowadays used in both sports, which seem to have a preventive effect, as has been shown in water polo. [6,10] Despite the protective caps, blows to the ears can cause perforation of the eardrum. In water polo these blows are mostly caused by the hands of opponents [10], whereas in UWR they were found to

be caused by fins [15]. In water polo, the head remains above the water surface and the ball is thrown at speeds of 60-70km/h thus representing a risk of injury [3,10]. In UWR, the ball is passed underwater and not thrown, and consequently did not cause any injuries in our study. Teeth or eye injuries, frequently found in water polo, were not found in our study. This difference could be explained by the different equipment used. In UWR, diving masks and snorkels are worn permanently. These can provide mechanical protection against impact and prevent contact of the eyes with the water. The latter is relevant because in water polo there is frequent irritation of the eye by chlorinated water and infections. [22] Several publications focusing on water polo found acute injuries mainly in the area of the head and face as well as the hands, while overuse injuries were found predominantly around the shoulders. [6,10,16,22,23,26] In their recent meta-analysis, Croteau et al. found head injuries to be the most common acute injuries in water polo (period prevalence of 20.5-53%). [6] In our study, head injuries represented the second most frequent localization of injury in UWR (18.1% of all acute injuries). Primary injury types in water polo were described to be contusions, concussions, cuts and fractures, and injuries to the teeth, eyes, and ears. In both sports ear drum ruptures are common types of injury. Protective caps are nowadays used in both sports, which seem to have a preventive effect, at least in water polo. [6,10] Despite the protective caps, blows to the ears can cause perforation of the eardrum. While in water polo, these blows are mostly caused by the hands of opponents [10], in UWR they were found to be caused by fins. In water polo, the head remains above the water surface and the ball is thrown at speeds of 60-70km/h thus representing a risk of injury [3,10]. The UWR ball, which is only moved underwater, did not cause any injuries in our study. Teeth or eye injuries, frequently found in water polo, were not found in our study. This difference could be explained by the different equipment used. In UWR, diving masks and snorkels are worn permanently. These can provide mechanical protection against impact and prevent contact of the eyes with the water. The latter is relevant because in water polo there is frequent irritation of the eye by chlorinated water and infections. [22]

A typical region for chronic overuse injuries, as well as acute injuries, in water polo is the shoulder. In a 2018 meta-analysis, Miller et al. reported rates of 24-51% shoulder pain and injury among male athletes [16]. Croteau et al. also described a prevalence of 6-13.6% shoulder injuries in water polo [6]. The combination of swimming and throwing movements in water polo has been cited as the cause of overuse injuries. The so-called "swimmer's shoulder" occurs frequently as a symptom complex [6,10,16]. In UWR, shoulder pathologies accounted for only 14.1% of chronic overuse injuries. One possible explanation is that UWR, in contrast to water

polo, does not involve an actual throwing motion. The ball is passed underwater with a pushing motion; load on the shoulders from crawling movements is also rare in UWR, since most distances are performed underwater by pushing with the legs/fins alone.

In swimming, a relationship between training volume and incidence of shoulder pain in swimmers has been reported. [2,8] Freestyle and backstroke swimmers show the highest risk of shoulder injury [21]. In UWR, the shoulder was the second most frequently affected by chronic overuse injuries (14.1% of all overuse injuries). Thus, these injuries occur significantly less frequently than in swimmers. Reasons could be that the training time of UWR players in the water is significantly lower than that of swimmers, some of whom have training durations of 20-30 hours per week [8,12]. Fins used in UWR also increase propulsion from the legs, which in turn could result in less stress on the shoulders. In swimmers, however, the knee is the second most frequently affected region with regards to overuse injuries.

Injuries to the thorax, spine, and lower extremity occurred less frequently than the above-mentioned injuries to the head and upper extremity in both water polo and UWR. Nevertheless, Fett et al. described an increased prevalence of back pain in both sports [9]. However, this could not be confirmed in the present study. In water polo, pathologies of the hip and knee can be favored by the breaststroke movement of the legs. Thus, tendinopathies and impingements may occur at the hip, while problems of the medial ligamentous apparatus (so-called "Breaststroker`s Knee") are prominent at the knee [6,10]. In UWR, knee complaints accounted for only 6.7% of overuse injuries. Reason for it could be that the problem of the "Breaststroker`s Knee" might not play a role. The swimming technique in UWR is most comparable to freestyle or dolphin swimming, which where stroke that are less often affected by knee pain. [12,25]

The back represents a frequent region of chronic complaints in swimmers [12,21,25] and increased degeneration of the intervertebral discs has been observed among swimmers. [14] A strong hyperextension of the lumbar spine during swimming is discussed as the cause of the complaints. It can be observed especially in breaststroke and dolphin swimming [25]. The severity of these complaints correlates with the amount of training. [9,14] Although the use of fins is considered a risk factor for chronic back pain [25], no increased complaints in the area of the thoracic or lumbar spine were found in UWR in this study.

Most available literature on UWR studied reported fractures of the hamate. In 2001, Andresen et al. published a case report of a professional UWR player with a fracture of the hamate sustained during a match [1]. An increased incidence of those fractures in UWR was elaborated in 2011 by Kamusella et al. using seven players [13]. Scheufler et al. came to the same conclusion in 2013. [20]. In all cases, the ball-carrying right hand was affected by the injury.

This is maximally inflected during ball control.[1,13,20]. In the present study, eight fractures of the carpal bones were recorded, seven of them hamate fractures (in one fracture, the affected bone was unknown). Kamusella et al. described the mechanism of hamulus fracture in UWR. Direct application of force to the palmar wrist on impact against the metal basket, is one cause of fracture. Repeated traumatic events by opposing players against the dorsum of the hand are another cause [13,20]. These mechanisms of injury are consistent with the descriptions in the present study. An increased incidence of those fractures in UWR was elaborated in 2011 by Kamusella et al. using seven players [13]. Scheufler et al. came to the same conclusion in 2013. [20]. In all cases, the ball-carrying right hand was affected by the injury. This is maximally inflected during ball control.[1,13,20]. In the present study, eight fractures of the carpal bones were recorded, seven of them hamate fractures (in one fracture, the affected bone was unknown). Kamusella et al. described the mechanism of hamulus fracture in UWR. Direct application of force to the palmar wrist on impact against the metal basket, is one cause of fracture. Repeated traumatic events by opposing players against the dorsum of the hand are another cause [13,20]. These mechanisms of injury are consistent with the descriptions in the present study. Sport-specific awareness training programs for noncompetitive and competitive UWR athletes to reduce burden of injury should be developed, and sports medical supervision is mandatory.

LIMITATIONS

This study is not without limitations. First, when evaluating the data, it should be noted that a niche sport was studied in which only provisional professional structures exist, and the training volumes vary greatly from individual to individual and are also considerably lower than in other sports. High-level athletes from this survey trained more than the comparison group, but still little compared to competitive athletes in other sports. Second, the data of the study were provided by the athletes themselves so that partly exact information for example on injury entities are missing and the differentiation between acute and chronic injuries sometimes was problematic. The OSTRC severity score was only collected once so that an approximate statement about the degree of severity of chronic injuries could be made. For an exact statement, however, monitoring of the athletes over a longer period would be necessary. Other potential risks underwater such as (near-) drowning were not investigated in this study but need to be considered, even though the authors are not aware of such cases. Despite the limitations the study shows a good systematic overview of typical injuries occurring in UWR.

CONCLUSION

Overall, significantly more acute than chronic injuries were recorded in this study, which is the largest difference compared to other swimming sports. Leading injury locations are hand/finger injuries, head/ear injuries, wrist and cervical spine injuries. Similarities between acute injuries in water polo and UWR are present, especially with respect to commonly occurring injuries to the head and hands. Acute injuries to the hand, finger, and thumb were the most common in UWR, mainly caused by fights for the ball or hits by opponents fins. Rare but typical injuries are hamate fractures. Overuse injuries have a mild severity according the OSTRC severity score. National team athletes have a higher rate of injuries during competitions and athletes playing in the first national league have an overall higher incidence of acute injuries. The knowledge gained can help to establish prevention concepts in the future.

Competing interest

None.

Approval

The study was approved by the institutional review board and all participating athletes provided informed consent.

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