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Main Text

INTRODUCTION

Aquatic sports are enjoyed around the world from the recreational level to the elite level. FINA (Federation Internationale de Natation), which was founded in 1908, was one of the original sports in the modern Olympic Games with the inclusion of swimming in 1896 (1). FINA has global representation with a total of 202 member National Federations. FINA has organized multidisciplinary aquatic World Championships since 1973 which are now held biannually. The 13th FINA World Championships held in Rome in 2009 was the largest aquatic event in the world with 2592 athletes participating from 172 countries.

Injury surveillance during elite events is a duty of care to ensure safety for future athletes (2, 3). FINA is increasingly emphasizing the protection of the health of the athlete. FINA Medical Rules: Preamble Item 1.0: “FINA, in accomplishing its mission, should take care that sport is practised without danger to the health of the athletes ... To that end, it takes the measures necessary to preserve the health of athletes and to minimise the risks of physical injury.” (4).

Although the aquatic sports enjoy worldwide participation, little is known of the incidence of injury for its participants at the elite level. Injury surveillance studies have been conducted in single sport events including football (5, 6, 7, 8, 9, 10), rugby (11, 12, 13, 14), handball (15), athletics (16), karate (17, 18, 19), ice hockey (20, 21), volleyball (22), beach volleyball (23), cycling (24), and tennis (25). Injury surveillance studies have occurred in large multisport events at the 2004 Athens Olympic Games for team sports and for all sports at the 2008 Beijing Olympic Games (26, 27). To the authors’ knowledge, no studies have been published on injuries

incurred during major events in elite aquatics. One prospective five-year study on NCAA collegiate swimmers has been published in the scientific literature on injury incidence (28). Injury prevalence in aquatic sports is published from the 2008 Beijing Olympic Games (27) and for water polo in 2004 Athens Olympic Games (26).

Although there are a limited number of publications on illness surveillance data at elite multi-sport events (29-31), aquatic specific illness incidence does not exist. Based on a previously standardized injury reporting system by the Federation International de Football Association (FIFA) in football (6-9), the IOC implemented an injury surveillance program during the 2004 Athens Olympic Games for team sports (26) and the 2008 Beijing Olympic Games for all sports (27, 32). In follow-up of the 2008 Beijing Olympic Games, the IOC decided to add illness surveillance for the 2010 Vancouver Winter Olympic Games. FINA conducted this current study to establish the feasibility of illness surveillance component as a pilot project for the 2010 Vancouver Winter Olympic Games.

The objectives of the current study were to record and analyze injuries and illnesses incurred during the 13th FINA World Championships 2009.

METHODS

Implementation

In this study, the IOC Injury Surveillance system (32) was implemented with the extension to also survey illness. All five disciplines of the 13th FINA World Championships 2009 (swimming, water polo, diving, synchronized swimming, open water swimming) were included as the study population. In preparation for the study, an information booklet was circulated one month in advance to the medical representatives of all participating countries. A site visit

occurred one month prior to the event by a member of the study group (MM) to educate the medical team of the Local Organizing Committee (LOC) on the logistics of the study. On-site in Rome, a voluntary information meeting was held for the medical teams of the visiting countries two days prior to the commencement of the Championships. These information sessions included instructions on completion and submission of the Reporting Forms. Instructional booklets and Reporting Forms were distributed. The team physicians, or in their absence, a team physiotherapist were asked to daily report on the occurrence (or non-occurrence) of all newly incurred injuries and illnesses. Reporting Forms could be submitted at a confidential mailbox adjacent to swimming pools. Reporting Forms were also accepted by fax and by electronic submission. Additional reporting forms were completed daily by the LOC medical team from each of the medical stations at the venues. Compliance was encouraged by regular visits to the national federation and LOC medical staff by members of the FINA Sports Medicine Committee.

Definitions of Injury and Illness

The definition of injury was the same definition as used in the IOC Injury Surveillance system (32), thus allowing comparison with previous studies (26, 27). An injury was defined as any musculoskeletal complaint and/or concussion newly incurred due to competition and/or training during the 13th FINA World Championships that received medical attention regardless of the consequences with respect to absence from competition and/or training. Pre-existing injuries were not included unless there was an acute exacerbation during the time period of the Championships. Injuries occurring not during training or competition were also excluded.

The definition of an illness was developed based on the injury definition to ensure compatibility with the existing injury protocol and ease of understanding for the participating physicians. An

illness was defined as any physical complaint (not related to injury) newly incurred during the 13th FINA World Championships that received medical attention regardless of the consequences with respect to absence from competition or training. Chronic pre-existing illnesses were not included unless there was an exacerbation requiring medical attention during the Championships.

Injury and Illness Report Form

The injury part of the report form was identical in design to the IOC Injury Surveillance System utilized during the 2008 Beijing Olympic Games (27, 32.). The following information was required for documentation: athlete's accreditation number, sport/event, heat/training, date and time of injury, injured body part/side, type and cause of injury, and estimated duration of the subsequent absence from competition and/or training. The illness part of the report form was located directly below the injury part on the same page. The following information was required for documentation: athlete's accreditation number, sport/event, diagnosis, date, main symptoms, cause of illness, and estimated duration of the subsequent absence from competition and/or training. Definitions of injury and illness parameters were stated on the back of the form. Examples of injuries and illnesses to be included on the report form were illustrated in the Instructional Booklet. The injury and illness report form was available in five languages (English, French, Spanish, Italian, and Russian).

Confidentiality & Ethical Approval

Completed injury and illness report forms were stored during the Championships in a locked storage cabinet. The accreditation number of the athlete was used to ensure that duplication of reporting was avoided from the team doctor and the LOC physicians, and to facilitate the determination of age and gender of the athlete from the FINA database. After the

Championships, the forms were made anonymous to ensure that no individual athlete or National Federation could be identified. Ethical approval was obtained from the Ethical Committee of the Oslo University School of Medicine.

Data analysis

All data were processed using Excel and SPSS. Response rate, coverage and incidences were calculated in accordance with the IOC approach for injury surveillance (32). Statistical methods applied were descriptive statistics, frequencies and cross-tabulations. For incidence rates, 95% confidence intervals (CIs) were calculated as the incidence ± 1.96 times the incidence divided by the square root of the number of injuries.

Results

Response rate and coverage

A total of 2592 athletes from 173 registered countries participated in the 13th FINA World Championships. The medical staff from 73 countries (42.2%) with a total of 1745 athletes (67.3%) participated in the project and returned at least one report form, resulting in a total of 495 report forms. Since some countries did not compete in all five disciplines of the FINA World Championships, response rates were calculated separately (see Table 1).

The response rate and coverage of athletes by team physician's reports were highest for water polo (53.4%) and lowest for swimming (21.8%).

Table 1

Acute injuries and illnesses were reported daily by the physicians at the medical stations at the different venues. The majority of injuries (140; 82.5%) were reported by the team physicians; 32

(17.5 %) injuries were reported by the LOC physicians. Only one injury was reported by both sources. About three quarters of the illnesses (n= 133, 72.3%) were reported only by the team physician, one quarter (n= 41, 22.3%) only from venues, and ten (5.4%) by both sources.

Frequency and characteristics of injury

There were 171 newly incurred acute injuries reported during the Championships; equivalent to an injury rate of 65.6/1000 athletes. Female athletes had a higher risk of injury (n=88; 68.4 per 1000 athletes CI95% 54.1 – 82.7) than male athletes (n=68; 52.1 per 1000 athletes CI95% 39.7 – 64.5). The oldest injured athlete was 37 years old, the youngest 14 (in 57 cases age was missing). Most injuries affected the upper extremity (n= 63; 36.8%), followed by the lower extremity (n= 47; 27.5%), head/neck (n= 33; 19.3%) and trunk (n= 28; 16.4%). The most frequently injured body parts were the shoulder (n=25; 14.6%), and head (n=21; 12.3%). The most common types of injury were sprains (n=41; 24.0%) and skin lesions (n=32; 18.7%) (see Table 2).

Table 2

Approximately half of the injuries (n= 79; 49.7%) were incurred during training or in competition (n=78; 49.1%), two injuries during warm-up for competition (in 12 cases the information was missing). On average, 7.2 in-competition injuries per 1000 starting athletes were reported. In most cases, the injury was caused by overuse (n=61; 37.5%). Other frequent causes of injury were non-contact trauma (n=25; 15.3%) and contact with another athlete (n=24; 14.7%).

Only 21 of the reported injuries (13.4%, 14 missing values) resulted in time-loss, which is equivalent to an 8.1 time-loss injury per 1000 registered athletes or less than 1% of the registered athletes. The five most severe injuries (estimated absence \geq 14 days) were a shoulder sprain, a

ligamentous rupture in the thoracic spine, a patellar subluxation, a tendon rupture in the hand and a broken finger.

The general injury risk was highest for diving (134.1/1000 female athletes) and lowest for swimming (21.8/1000 female athletes), the risk of an in-competition injury was highest in open water swimming (57.7/1000 starts of female athletes) and water polo (23.8/1000 starts of male athletes). There were no time-loss injuries incurred in women's open water swimming and women's diving. Injuries expecting a time-loss of greater than 14 days occurred in male water polo, swimming and in male open water swimming (see Table 3). While in swimming, synchronized swimming and diving most injuries were incurred during training, in open water swimming, synchronized swimming and water polo the majority of injuries occurred during competitions.

Table 3

Frequency and characteristics of illness

A total of 184 acute illnesses were reported, which is equivalent to 7.1% of the registered athletes suffering an illness during the Championships. About half of the illnesses affected the respiratory system (n= 91; 50.3%) and a fifth the gastro-intestinal system (n= 36; 19.9%). The most commonly reported symptom was pain. The most frequent diagnosis affected the upper respiratory tract including "otitis" (n= 31; 16.8%) and "tonsillitis" (n= 18; 9.8%). Consequently, the cause was most frequently classified as infection (n= 89; 49.2%) or environmental (n=50; 27.6%).

Thirty (16.3%) of the illnesses were expected to result in time-loss from sport inferring that only 1.2% of all registered athletes incurred a time-loss illness. However, time-loss illnesses were

only reported from swimmers and male water polo players (see Table 3). No illness was expected to result in absence from sport longer than a week.

Discussion

The aim of this study was to register and analyze all newly incurred injuries and illnesses in athletes participating in the 13th FINA World Championships 2009. To the authors' knowledge, this is the first injury and illness survey during an international aquatic event. The results indicate that the surveillance system was feasible and accepted by both the team physicians and the local medical staff. In all disciplines (except swimming) over 50% of all athletes were covered by the team physicians' reports. Although medical reports were also received from LOC medical team at the medical stations at each competitive and training venues, the incidence of injuries and illnesses may be under-estimated due to the response rate indicated above.

On average, less than seven percent of all registered athletes incurred injuries during the Championships. This injury rate is consistent with the injury incidence in aquatics reported during the 2008 Beijing Olympic Games (4.25%) (27). The incidence of acute injury in swimming during the World Championships was substantially lower than in a five-year longitudinal study in NCAA Division I Colleges in the United States (4/1000 exposures) (28), which includes chronic injuries in addition to acute new onset injuries.

Most injuries incurred during the FINA World Aquatic Championships affected the upper extremity followed by the lower extremity, trunk and head/neck. The most frequently injured body regions were the shoulder, low back and head. These findings are consistent with other published data in swimming where the shoulder was the most affected joint. (31, 33, 34, 35, 36)

These findings differ however from the 2008 Olympic Games where about half of the injuries

affected the lower extremity (27) and the 2007 IAAF World Championships where 80% of all injuries affected the lower extremity (16). This discrepancy is not surprising given the obvious differences in biomechanics between swimming and athletic disciplines. The injury location data obtained in this study illustrate the need in aquatic sport to focus injury prevention programs on the shoulder.

In most cases, overuse injuries were reported as the cause of injury (37.5%). Other causes identified were non-contact trauma (15.3%) and contact with another athlete (14.7%). All five time-loss injuries in water polo were caused by contact with another player, while seven time-loss injuries in swimming were caused by overuse and the other five by non-contact trauma. Attention to the prevention of overuse injuries should be a focus of aquatic injury prevention programs.

In the present study the proportion of in-competition injuries (50%) was lower than in team sports during the 2004 Olympic Games (75%) (26), in athletics during the 2007 IAAF World Championships (74%) (16) and all sports during the 2008 Olympic Games (75%) (27). Only 21 injuries (13.4%) reported in the present study were expected to result in time-loss from sport. This proportion is substantially lower than reported from the 2008 Olympic Games (49.6% (27)), the 2007 Athletics World Championships (56% (16)) and the recent FIFA World CupsTM (63-67% (8)). The data from the present study indicate that on average, less than 1% of the registered athletes incurred a time-loss injury during the FINA World Championships 2009. Even if this result may be an underestimation due to the moderate response rate, these data would suggest a relative low risk of serious time-loss injury in aquatic sports in comparison with other sports.

During the FINA World Championships in Rome 2009 slightly more illnesses than injuries were reported. These data contrast with the findings at the 1996 Olympic Games where more athletes were treated for injury (52%) than for illness (43%) (31). The overall rate of illness from the Rome data was 7.1% of registered athletes. Approximately half of the illnesses reported affected the respiratory system. These findings are consistent with prevalence data from other elite sporting events such as the Olympic Games in 1996 (31), 2000 (29), and 2004 (30). Results published from a prospective analysis of upper respiratory tract infections (URI) in athletes during training and in-competition shows that URI are more common in elite athletes than in non-competitive athletes (37). This is thought to be due to the increased risk of infection from such factors as over training-induced “immuno-suppression” and from crowding at competition venues (38). This is supported by the data from Rome where the highest incidence of illness was reported in swimming with the highest number of competitors exposed to more crowding in warm-up areas and event call rooms. The most frequent diagnosis of illness was otitis (n=31). Beck (38) reports that ear infections are common in aquatic sports relating to exposure to water borne pathogens. No illness was expected to result in absence from sport longer than one week. Very few illnesses were related to exercise induced causes or environmental causes. This is in contrast to the data reported in the literature on other elite sporting events such as marathon running (39).

At future FINA World Championships, attention to strategies to encourage compliance with reporting will improve the quality of the injury and illness surveillance program. The institution of injury prevention programs based on the findings from this study will be implemented and evaluated at future FINA World Championships.

Conclusion

The injury and illness surveillance system was accepted by the majority of the medical personnel at the 13th FINA World Championships demonstrating its feasibility for any large international multidisciplinary event. Attention to improving compliance in reporting at future FINA World Championships will strengthen the quality of the results. The findings are consistent with studies in other sports using a similar methodology. Less than seven percent of the registered athletes were injured during the Championships with most injuries caused by overuse. The most commonly affected body part was the upper extremity. The incidence and characteristics of injury varied by discipline, with the lowest injury risk in swimming and the highest in water polo and open water swimming. Approximately seven percent of all registered athletes suffered an illness during the Championships with about half affecting the respiratory system. In swimming, prevention studies should focus on overuse injuries with emphasis on the upper extremity. Medical care at future FINA World Championships should institute measures to decrease the incidence of respiratory illnesses.

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Competing Interests

None declared

Provenance and Peer Review

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Table 1: Characteristics and team physicians' response rates for the five aquatics disciplines

	Swimming	Open Water Swimming	Diving	Synchronized Swimming	Water Polo
No of athletes	1502*	155*	200	281	461
No of countries	170	41	42	41	21
Days of competition	8 26.7. - 2.8.	5 19. - 25.7.	9 17. - 25.7.	8 18. - 25.7.	14 19.7.-1.8.
No of returned report forms	296	73	141	126	157
Response rate	21.8%	35.6%	37.3%	38.4%	53.4%
Coverage of athletes by team physicians	41.1%	56.5%	52.7%	53.1%	56.7%

* 7 athletes registered for Swimming and Open Water Swimming

Table 2: Number and diagnosis of all (time-loss) injuries in the championship and in the 5 disciplines

Location and diagnosis	number of all (<i>time-loss</i>) injuries					
	total	Swimming	Open Water Swimming	Diving	Synchronized Swimming	Water Polo
Head / face	16 (3)	5 (1)	1 (*)	0	1 (0)	9 (2)
concussion	2 (2)	1 (1)	-	-	-	1 (1)
sprain	2 (0)	-	-	-	-	2 (0)
contusion	4 (0*)	1 (0)	1 (*)	-	1 (0)	1 (0)
skin lesion	4 (1)	-	-	-	-	4 (1)
others	4 (0)	3 (0)	-	-	-	1 (0)
Cervical spine / neck	10 (1)	3 (1)	0	3 (0)	2 (0)	2 (0)
sprain / strain	5 (0)	2 (0)	-	3 (0)	-	-
muscle cramps	3 (1)	1 (1)	-	-	-	2 (0)
others	2 (0)	-	-	-	2 (0)	-
Lumbar spine / low back	15 (2)	5 (2)	0	5 (0)	0	5 (0)
sprain / strain	7 (0)	3 (0)	-	2	-	2
muscle cramps	6 (0)	-	-	3	-	3
enthesopathy / fasciitis	2 (2)	2(2)	-	-	-	-
Other trunk	8 (1)	2 (0)	0	0	2 (0)	4 (1)
thoracic spine	4 (1)	-	-	-	-	4 (1)
sternum / ribs / chest muscles	3 (0)	1 (0)	-	-	2 (0)	-
abdomen	1 (0)	1 (0)	-	-	-	-
Shoulder	22 (4*)	9 (3)	3 (1*)	0	4 (0)	6 (0*)
dislocation	2 (1)	1 (1)	-	-	-	1 (0)
sprain	3 (0)	1 (0)	-	-	2 (0)	-
strain	3 (2*)	1 (1)	1 (1)	-	-	1 (*)
contusion	4 (0)	2 (0)	-	-	-	2 (0)
tendinosis	4 (1)	2 (1)	1 (*)	-	1 (0)	-
inflammation, bursitis	2 (0)	1 (0)	-	-	-	1 (0)
impingement	2 (0)	1 (0)	-	-	-	1 (0)
others	2 (0)	-	1 (*)	-	1 (0)	-
Arm / elbow	14 (0*)	0	2 (0*)	3 (0)	1 (0)	8 (0)
sprain	3 (0)	-	-	-	-	3 (0)
strain	2 (0)	-	-	2 (0)	-	-
contusion	3 (0)	-	1 (0)	-	-	2 (0)
tendinosis	2 (0)	-	-	1 (0)	-	1 (0)
others	4 (0*)	-	1 (*)	-	1 (0)	2 (0)
Wrist / hand	21 (3)	9 (1)	0	5 (0)	1 (0)	6 (2)
fracture	2 (2)	1 (1)	-	-	-	1 (1)
tendon rupture	1 (1)	-	-	-	-	1 (1)
sprain	7 (0)	1 (0)	-	3 (0)	-	3 (0)
contusion	2 (0)	2 (0)	-	-	-	-
skin lesion	9 (0)	5 (0)	-	2 (0)	1 (0)	1(0)

Table 2 continues

Table 2 continues

Location and diagnosis	total	Swim ming	Open Water Swimming	Diving	Synchronized Swimming	Water Polo
Hip / groin	10 (1)	5 (1)	0	0	2 (0)	3 (0)
strain (hip/groin)	6 (1)	3 (1)	-	-	2 (0)	1 (0)
tendinopathy (hip)	3 (0)	2 (0)	-	-	-	1 (0)
impingement (hip)	1 (0)	-	-	-	-	1 (0)
Thigh / lower leg	9 (0)	1 (0)	0	2 (0)	5 (0)	1 (0)
strain	5 (0)	1 (0)	-	-	4 (0)	-
contusion	2 (0)	-	-	-	1 (0)	1 (0)
skin lesion	1 (0)	-	-	1 (0)	-	-
cramps	1 (0)	-	-	1 (0)	-	-
Knee	10 (3)	3 (2)	0	4 (1)	2 (0)	1 (0)
subluxation	1 (1)	1 (1)	-	-	-	-
sprain	3 (0)	-	-	1 (0)	2 (0)	-
contusion	2 (0)	1 (0)	-	1 (0)	-	-
tendinosis	1 (1)	1 (1)	-	-	-	-
skin lesion	2 (0)	-	-	1 (0)	-	1 (0)
Osgood-schlatter	1 (1)	-	-	1 (1)	-	-
Ankle / foot	16 (2)	1 (1)	0	9 (0)	4 (1)	2 (0)
fracture	2 (1)	-	-	1 (0)	1 (1)	-
sprain (ankle)	3 (1)	1 (1)	-	2 (0)	-	-
sprain / strains (foot)	5 (0)	-	-	2 (0)	2 (0)	1 (0)
contusion	2 (0)	-	-	1 (0)	1 (0)	-
skin lesion#	4 (0)	-	-	3 (0)	-	1 (0)
Multiple	13 (1)	5 (0)	4 (0)	2 (1)	2 (0)	0
eye bruise + shoulder - subluxation	1 (0)	1 (0)	-	-	-	-
eye contusion + hand - sprain	1 (0)	-	1 (0)	-	-	-
cervical + thorasic spine – sprain	1 (0)	1 (0)	-	-	-	-
cerv. spine, shoulder/arm - strain	1 (0)	1 (0)	-	-	-	-
neck + upper back – tight muscles	1 (0)	1 (0)	-	-	-	-
thor. spine, sternum/ribs – sublux.	1 (1)	-	-	1 (1)	-	-
thor. + lumb. spine - muscl. spasm	2 (0)	-	-	-	2 (0)	-
thigh + lower leg – skin lesion	1 (0)	-	-	1 (0)	-	-
head + shoulder - skin lesion	1 (0)	-	1 (0)	-	-	-
head + arm / hand – skin lesion	2 (0)	-	2 (0)	-	-	-
multiple – skin lesion	1 (0)	1 (0)	-	-	-	-
missing information	6 (0)*	0	5 (0)*	0	1 (0)	0

* Information on time-loss is missing in at least one injury;

Information on sport is missing in one case

Table 3. Injuries and illnesses occurring during training and competition including time-loss from sport at the FINA World Aquatic Championships.

	Swimming ^a		Open water swimming ^a		Diving		Synchro	Water polo		Total
	Women	Men	Women	Men	Women	Men	Women	Women	Men	
Athletes	630	872	74	81	82	118	281	226	235	2592
Athletes' starts	2369	2967	104	110	1325	1866	990	672	672	11075
Acute injuries^b	22	19	7	8	11	14	28	23	21	171
Injuries per 1000 athletes	34.9	21.8	94.6	98.8	134.1	118.6	99.6	101.8	89.4	65.6
Training	13	13	0	1	8	9	12	7	11	79
Competition	9	6	6	7	3	5	7	16	10	80
Competition injuries per 1000 starts	3.80	2.02	57.7	52.5	2.26	2.68	7.07	23.8	14.9	7.2
Time-loss^c	2	10	0	1	0	1	1	2	3	21
≥ 14 days^c	1	1	0	1	0	0	0	0	2	5
Acute illnesses	59	53	3	1	0	4	7	18	9	184
Illnesses per 1000 athletes	93.7	60.8	40.5	12.3	0	33.9	24.9	79.6	28.3	71.0
Time-loss^c	12	14	0	0	0	0	0	0	3	30

^a 6 female and one male athletes participated in swimming and open water swimming

^b sex missing in 18 injuries and 28 illnesses, ^ctime loss is missing in 14 injuries and 7 illnesses