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Handball injuries during major international tournaments

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Background: **Several authors have analyzed the incidence of handball injuries in amateur players but information of handball injury in top-level players is very limited. The aim of the study was to analyze the incidence, circumstances and characteristics of handball injuries during major international tournaments.** *Methods:* **Injuries during six international handball tournaments were analyzed, using an established injury report system. The physicians of all participating teams were asked to report all injuries after each match on a standardized injury report form. The response rate was on average 87%.** *Results:* **The incidence of injury was on average 108 injuries/1000 player hours (95% confidence interval (CI): 98–117) or 1.5 injuries/match (95% CI: 1.4–1.6). The injuries affected most frequently the lower extremity (42%), followed by injuries of the head (23%), upper extremity (18%) and trunk (14%). The most frequent diagnosis was contusion of head (14%) or ankle sprain (8%). The majority of injuries were caused by contact with another player. The incidence of time loss injuries was on average 27/1000 player hours (95% CI: 22–32), and significantly higher in men than in women.** *Conclusion:* **Preventive program proven effective should be implemented. Fair Play is an essential aspect of injury prevention. Therefore, close cooperation with the referees is also necessary to make handball a safer sport.**

Introduction

Team handball is a high-intensity sport with frequent physical contact between the players. It has been an Olympic sport since 1972, and is one of the most popular sports in Europe after football, volleyball and basketball. The International Handball Federation (IHF) officially numbers 150 member federations representing approximately 800 000 teams and more than 19 million sportsmen and -women (IHF 2004; www.ihf.inf).

Several authors have analyzed the incidence of handball injuries, but the results are difficult to compare because of heterogeneous study design, injury definition, observation periods and level of play. In some of the studies, injuries were assessed using retrospective questionnaires or interviews (Leidinger et al., 1990; Seil et al., 1997; Wedderkopp et al., 1997; Reckling et al., 2003), other documented prospectively injuries during the season (Nielsen & Yde, 1988; Yde & Nielsen, 1990; Backx et al., 1991; Seil et al., 1998; Wedderkopp et al., 1999; Olsen et al., 2005) and one study used video analysis (Oehlert et al., 2004). However, most of the studies evaluated injuries (Nielsen & Yde, 1988; Yde & Nielsen, 1990; Backx et al., 1991; Wedderkopp et al., 1997; Reckling et al., 2003) or the effects of preventive program (Wedderkopp et al., 1999; Olsen et al., 2005) in adolescent players. Only two studies reported prospective data on handball injuries of adult amateur players during the season (Nielsen & Yde, 1988; Seil et al., 1998), and two further studies analyzed injuries during international tournaments (Asembo & Wekesa, 1998; Oehlert et al., 2004).

Asembo and Wekesa (1998) recorded all injuries that led to a temporary stoppage of the game or the substitution of the injured players during the East and Central Africa Senior Clubs Championship in 1995 in Kenya. All injured players were examined after the match in collaboration with the team physician. The authors reported an average incidence of 2.7 injuries/match in male players and 1.5 injuries per match in female players, with contusions being the most frequent type of injury.

Oehlert et al. (2004) analyzed video recordings of 59 injuries during the Olympic Games 1992 in Barcelona, Spain. The injury definition applied was similar to that of Asembo and Wekesa (1998), but no additional medical information (e.g. from the team physician) was available. The study mainly focused on injury mechanism in male players, and injury incidences were not reported.

From the review of the literature, it can be concluded that information of handball injury in top-level players is very limited. However, a comparative study on injuries in eight team sports during the Olympic Games 2004 in Athens showed that the incidence of injuries was the highest in handball and football (Junge et al., 2006).

Standardized assessment of sports injury provides not only important epidemiological information but also the opportunity for monitoring long-term changes in the frequency and circumstances of injury and for comparison with other types of sports (Junge et al., 2006).

The purpose of the present study is to analyze the incidence, circumstances and characteristics of team handball injuries during the major international tournaments. These data are important as it will give a background for preventive efforts and the work of making handball a safer sport.

Methods

The injury-reporting system applied in the present study was developed for the documentation of injuries during team sports tournaments and has been implemented in several international football tournaments (Junge et al., 2004a, b; Yoon et al., 2004) and in eight different team sports during the Olympic Games 2004 in Athens (Junge et al., 2006).

During a pre-tournament instructional meeting, the physicians of all teams participating were asked to report all injuries incurred during the tournament and were informed about how to fill in the injury report forms. The injury report form comprised a single page on which all injuries during a given match or, where applicable, the non-occurrence of injury was described in tabular form (Junge et al., 2004b). An injury was defined as any physical complaint incurred during the match that received medical attention from the team physician regardless of the consequences with respect to absence from the match or training. For each match, both team physicians should return the completed form for their team to a medical representative of the IHF. Confidentiality of all information was ensured. The methodology was identical to that previously used for football tournaments, except for the exchange of the word "football" to "handball" in the injury report form.

Calculation of incidence and statistical analysis

The incidence of injury was expressed as (a) number of injuries/match and (b) number of injuries/1000 player hours. The total player hours were computed as: seven players $\times$ 1 h $\times$ number of returned injury report forms.

The statistical methods applied were frequencies, cross-tabulations, descriptive statistics and χ^2 test. For incidence rates, 95% confidence intervals (CIs) were calculated according to the following formula: 95% CI = incidence $\pm$ 1.96 $\times$ (incidence/square root (number of incidents)). Significance was accepted at the 5% level.

Tournaments

Starting with the Olympic Games 2000, the injuries during eight international handball tournaments have been surveyed. Initially, the response rate was low, but the compliance of the team physicians improved and the injury-report system became a matter of routine.

In the present study, the data of six tournaments are included: Men's World Cups 2001 and 2003, Women's European Handball Championship 2002, Women's World Cup 2003 and the tournaments for men and women during the Olympic Games 2004. These tournaments comprised 365 matches, equivalent to 5110 player hours. A total of 635 injury report forms, covering 4445 player hours, were filled out and returned to the medical officers of the IHF. The response rate was on average 87%, ranging from 76% for the men's World Cup 2003 to 98% for the women's World Cup 2003 (for details, see Table 1).

Results

A total of 478 injuries were reported from the six tournaments, which is equivalent to an incidence of 108 injuries/1000 player hours (95% CI: 98–117) or 1.5 injuries/match (95% CI: 1.4–1.6). The incidence of injuries that were expected to result in absence from a match or training session was 27 injuries/1000 player hours (95% CI: 22–32) or 0.37 injuries/match (95% CI: 0.30–0.44).

Most injuries were incurred due to contact with another player; only 16% were non-contact injuries (72 of 457). Half of the contact injuries (167 of 310), or 45% of all injuries, were caused by foul play as judged by the team physician and the injured player, although only 60% of these (98 of 163) were followed by a sanction of the referee.

The injuries affected most frequently the lower extremity ($n = 197$; 42%), followed by injuries of the head and neck ($n = 124$, 26%), upper extremity ($n = 85$; 18%) and trunk ($n = 68$; 14%). The body parts injured were predominantly the head ($n = 109$; 23%) and knee ($n = 62$; 13%), followed by ankle ($n = 50$; 11%), hand ($n = 40$; 8%) and thigh ($n = 36$; 8%). The majority of injuries ($n = 257$; 56%) were diagnosed as contusions. Sprains ($n = 74$; 17%) were also frequent, and strains or muscle fiber ruptures ($n = 32$; 6%) were less numerous. Twenty-one injuries were diagnosed as being a ligament rupture, 12 as concussion, nine as dislocation, six as fracture, two as lesion of meniscus and one as tendon rupture (for detail, see Table 2). The most frequent diagnoses were contusion of the head ($n = 65$; 14%), ankle sprain ($n = 38$; 8%) or contusion of the knee ($n = 31$; 6%).

An estimate of the anticipated duration of absence from handball after injury was available for 389 (81%) injuries. The majority of the injuries reported ($n = 278$; 72%) were not expected to result in subsequent absence from training or matches. Less than a quarter of the injuries ($n = 90$; 23%) prevented the player from participating in a match or training for up to 1 week, and further 5% of the injuries led to longer absence. Regarding time loss injuries only, the

Table 1. Characteristics of injuries in different tournaments

Tournament	World Cup Men 2001	World Cup Men 2003	Olympiad Men 2004*	Europe Cup Women 2002	World Cup Women 2003	Olympiad Women 2004*
Number of matches	80	80	44	48	80	33
Response rate	125 (78%)	122 (76%)	79 (90%)	88 (92%)	157 (98%)	64 (97%)
Player hours documented	875	854	553	616	1099	448
Number of injuries	96	110	49	52	106	65
Injuries/1000 h	110	129	89	84	96	145
Injuries per match	1.5	1.8	1.2	1.2	1.3	2.0
Circumstances						
Non-contact injuries	18 of 92 (20%)	8 of 106 (8%)	4 of 48 (8%)	5 of 50 (10%)	25 of 98 (25%)	12 of 63 (19%)
Contact injuries	74 of 92 (80%)	98 of 106 (92%)	44 of 48 (92%)	45 of 50 (90%)	73 of 98 (75%)	51 of 63 (81%)
Contact injury caused by foul	25 of 46 (54%)	34 of 77 (44%)	18 of 36 (50%)	19 of 45 (42%)	37 of 67 (55%)	34 of 44 (77%)
Foul sanctioned by the referee	11 of 23 (48%)	18 of 34 (53%)	10 of 16 (63%)	10 of 15 (67%)	22 of 39 (56%)	25 of 34 (74%)
Minute of the match						
First half						
1–10	9 (11%)	11 (10%)	6 (13%)	4 (8%)	7 (7%)	7 (11%)
11–20	11 (13%)	23 (22%)	7 (15%)	11 (21%)	20 (21%)	10 (16%)
21–30	11 (13%)	22 (21%)	6 (13%)	7 (13%)	19 (20%)	12 (19%)
Second half						
31–40	19 (22%)	17 (16%)	5 (11%)	7 (13%)	16 (16%)	8 (13%)
41–50	27 (32%)	23 (22%)	16 (35%)	15 (29%)	25 (26%)	14 (22%)
51–60	7 (8%)	6 (6%)	6 (13%)	8 (15%)	8 (8%)	11 (17%)
Overtime	1 (1%)	3 (3%)	0	0	2 (2%)	1 (2%)
Estimated duration of absence						
0 days	45 (62%)	63 (72%)	21 (50%)	40 (83%)	68 (80%)	41 (77%)
1–3 days	14 (20%)	16 (18%)	16 (38%)	5 (10%)	8 (9%)	7 (13%)
4–7 days	9 (13%)	4 (5%)	1 (2%)	2 (4%)	5 (6%)	3 (6%)
> 1 week <1 month	3 (4%)	1 (1%)	3 (7%)	1 (2%)	2 (2%)	
>1 month	1 (1%)	5 (6%)	1 (2%)	0	2 (2%)	2 (4%)
Missing	24	21	7	4	21	12
Time-loss injuries	27	29	22	8	17	16
Injuries/1000 h	31	34	40	13	15	36
Injuries per match	0.4	0.5	0.6	0.2	0.2	0.5
	N (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)
Injured body part						
Head, neck	11 (11%)	30 (28%)	15 (32%)	15 (29%)	30 (29%)	23 (35%)
Trunk	16 (17%)	14 (13%)	5 (11%)	4 (8%)	20 (19%)	12 (18%)
Upper extremity, including shoulder	21 (22%)	21 (19%)	10 (21%)	8 (16%)	18 (17%)	7 (11%)
Shoulder	4 (4%)	3 (3%)	4 (9%)	2 (4%)	1 (1%)	2 (3%)
Arm (upper arm/forearm)	2/ – (2%)	1/1 (2%)	2/ – (4%)	1/ – (2%)	1/ – (1%)	– /1 (1.5%)
Elbow	7 (7%)	6 (6%)	0	2 (4%)	3 (3%)	2 (3%)
Hand, including finger, wrist	8 (8%)	10 (9%)	4 (9%)	3 (6%)	13 (12%)	2 (3%)
Hip/groin	4 (4%)	3 (3%)	2 (4%)	1 (2%)	1 (2%)	1 (1.5%)
Thigh	7 (7%)	8 (7%)	2 (4%)	9 (18%)	6 (6%)	4 (6%)

Knee	15 (16%)	15 (14%)	5 (11%)	5 (10%)	12 (11%)	10 (15%)
Lower leg	13 (14%)	1 (1%)	3 (6%)	3 (6%)	3 (6%)	3 (5%)
Ankle	7 (7%)	14 (13%)	7 (15%)	5 (10%)	12 (11%)	5 (8%)
Foot/toe	2 (2%)	3 (3%)	1 (2%)	2 (4%)	3 (3%)	0
Missing	0	1	2	0	1	0
Type of injury						
Concussion	1 (1%)	4 (4%)	1 (2%)	2 (4%)	3 (3%)	1 (1.6%)
Fracture	1 (1%)	1 (1%)	2 (4%)	0	1 (1%)	1 (1.6%)
Dislocation	3 (3%)	2 (2%)	2 (4%)	0	1 (1%)	1 (1.6%)
Tendon/ligamentous rupture, meniscus lesion	4 (4%)	3 (3%)	5 (11%)	1 (2%)	6 (6%)	5 (8%)
Sprain	10 (11%)	29 (27%)	3 (7%)	5 (10%)	18 (17%)	9 (14%)
Strain/muscle fiber rupture	7 (8%)	7 (6%)	2 (4%)	3 (6%)	6 (6%)	9 (14%)
Contusion	57 (63%)	48 (44%)	25 (54%)	40 (77%)	54 (51%)	33 (52%)
Tendonitis/bursitis	2 (2%)	0	0	1 (2%)	0	
Laceration/abrasion/blister	1 (1%)	7 (6%)	1 (2%)	0	8 (8%)	2 (3%)
Others	5 (6%)	7 (6%)	5 (11%)	0	8 (8%)	5 (8%)
Missing	5	2	3	0	1	1

*Data previously published (Junge et al., 2006).

sequence of the most frequently injured body parts changed to ankle ($n = 21$; 18%), knee ($n = 16$; 13%) and head ($n = 16$; 13%). Ankle sprain ($n = 12$; 10%) was the most frequent diagnosis. The 11 injuries with an estimated absence of a month or more comprised six knee injuries (five ligament ruptures, one lesion of meniscus), a fracture of a finger, a fracture of the head, a muscle fiber rupture in the groin, a tendon rupture in the lower leg and a ligament rupture in the ankle.

Significantly more non-contact injuries (44%, 27 of 61) than contact injuries (27%; 87 of 320) were expected to result in absence from handball ($P < 0.01$). There were no significant differences between contact injuries with and without time loss in relationship with foul play (based on the judgment of the team physician).

The incidence and mechanism of injury varied during the course of the match. In general, the incidence of injuries increased toward the middle of each half and decreased toward their ends (Fig. 1). The pattern was similar in all six tournaments and slightly more pronounced in the second half (Table 1). Thus, 45% of all injuries occurred in the middle 10 min of both halves (minutes 11–20 and 41–50). In this period of the match, 58% of the non-contact injuries (40 of 69) were incurred. Time loss injuries seem to be more equally distributed over the course of the match, but 60% of non-contact time loss injuries (15 of 25) were incurred in only a third of the match time.

The incidence of injury varied between the different types of tournaments; it was the lowest in the European Cup of women 2002 and the highest in the women's tournament of the Olympic Games 2004 (for details, see Table 1). Regarding time loss injuries only, the incidence was the highest in the Olympic Games in men and women, and the lowest in the Europe Cup and the World Cup of women.

Overall, the incidence of injury was similar for men and women (112 vs 103 injuries/1000 player hours). Furthermore, the location and type of injuries did not vary significantly between men and women, and the variation of the incidence of injury during the match had a similar pattern in men and women. Women incur significantly more non-contact injuries than men (20% vs 12%; $P < 0.001$), and significantly less injuries of women than of men were expected to result in absence from handball (38% vs 22%; $P < 0.001$). The results concerning time loss injuries might be biased because the information about the estimated duration of absence was missing in almost 20% of the injuries. However, missing data were more frequent in the men's than in the women's tournaments; thus, the difference in the incidence of time loss injuries between men and women could even be more pronounced. Thus, the incidence of

Table 2. Diagnosis of injuries

Location and type	Number of injuries (total)	Without absence	With absence
Head/neck	124 (26%)		21 (18%)
Concussion	12	6	6
Fracture	3	0	3
Sprain	1	1	0
Strain	4	0*	3*
Contusion	75	62*	6*
Laceration	13	10*	1*
Others	13	10*	2*
Not specified	3	0*	0*
Trunk	68 (14%)		13 (11%)
Fracture	2	0	2
Strain	3	1*	1*
Contusion	52	32*	7*
Laceration	1	0*	0*
Others	8	5	3
Not specified	2	1*	0*
Upper extremity	85 (18%)		23 (19%)
Fracture	1	0	1
Rupture of ligament	6	3	3
Dislocation	6	0*	4*
Strain/muscle rupture	4	1*	1*
Sprain	22	15*	1*
Contusion	40	24*	11*
Laceration	1	1	0
Others	2	2	0
Not specified	3	0*	2*
Lower extremity	197 (42%)		62 (52%)
Rupture of ligament	15	2*	12*
Rupture of tendon	1	0	1
Lesion of meniscus	2	1	1
Dislocation	3	0	3
Strain/muscle rupture	21	10*	8*
Sprain	50	23*	17*
Contusion	88	58*	19*
Tendonitis	3	1*	1*
Laceration	3	3	0
Others	7	5*	0*
Not specified	4	0*	0*
Unclear	4 (1%)		0
Sprain	1	0*	0*
Contusion	2	1*	0*
Laceration	1	0*	0*

*Information is missing for at least one injury.

time loss injuries was significantly higher in men (34 injuries/1000 player hours; 95% CI: 26–42) than in women (19 injuries/1000 player hours; 95% CI: 13–25).

Discussion

This is the first study on handball injuries of high-level male and female players during international tournaments. A standardized injury report system well established for football tournaments (Junge et al., 2004b) and proven feasible for other team sports (Junge et al., 2006) was utilized.

Initially, not all team physicians reported injuries in their team to the IHF, but the compliance with the procedure increased and the injury-reporting system became a matter of routine, as demonstrated by the response rates of up to 98%. In the present study, only tournaments with a minimum response rate of 75% were included to avoid any bias by incomplete reporting. However, it cannot be proven that all injuries, especially all minor ones, were reported. As a consequence, the incidence of injury could have been underestimated, i.e. the "true" incidence of injuries could be even higher than reported. Another limitation of the study is that all information was collected a short time after the injury and that the injured players were not followed up. Thus, the duration of absence was just an estimate of the team physician and should be regarded with caution.

The incidence of injury in the present study was similar to the injury rate of female players during the East and Central Africa Senior Clubs Championship, but substantially lower than the men's injury rate in this tournament (Asembo & Wekesa, 1998). However, it was approximately twice as high as the incidence of match injuries of adult amateur players during a season (Nielsen & Yde, 1988; Seil et al., 1998). The substantially higher injury rate during tournaments of top-level players is probably caused by several factors, such as the higher speed of the game, the tougher play and the high number of matches during a short period of time. Thus, the injuries reported from the East African senior club championship is probably the study that compares best with the present one. A difference in the incidence of injury between male and female players as reported by Asembo and Wekesa (1998) was, in the present study, only found for time loss injuries but not for all injuries. However, the injuries of female and male handball players were similar in almost all characteristics. The risk of injury in different playing positions, previously reported by other authors (e.g. Wedderkopp et al., 1997; Oehlert et al., 2004), was not regarded in the present study. Future studies should include this variable to analyze more closely playing position as a possible risk factor.

An important finding of the present study is that the head was the most frequently injured body part, followed by knee and ankle. The high number of head injuries in handball tournaments was previously also observed by Asembo and Wekesa (1998) and Oehlert et al. (2004). In this context, it is important to mention that these studies did not restrict their injury definition to time loss. More than half of the injuries (59%) incurred during the East and Central Africa Senior Clubs Championship 1995 affected the head Asembo and Wekesa (1998), and approximately one-third (20 of 59) of the injuries analyzed from video tapes of the handball tournaments during the Olympic Games 1992 Oehlert et al. (2004). The somewhat lower incidence of head injuries in the present study (26%) might be caused by differences in injury

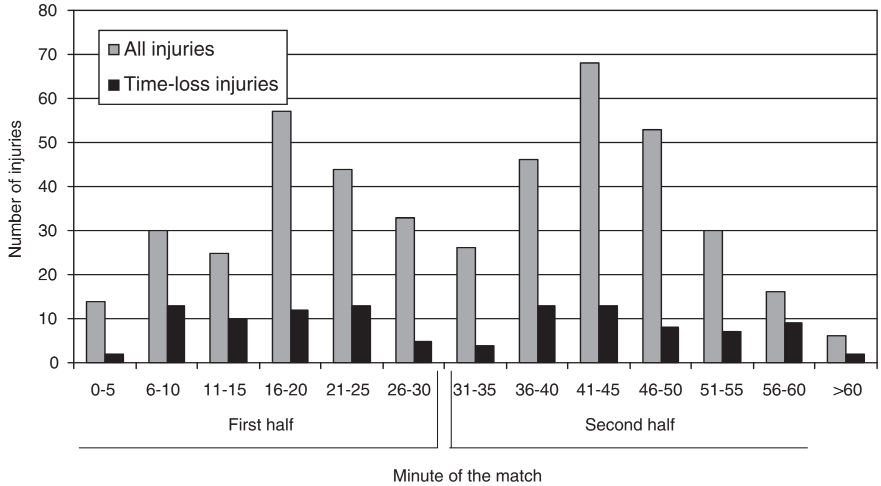

Fig. 1. Number of all injuries and time loss injuries only in relation to time in the match.

definition and assessment. Thus, the proportion of head injuries declined to 18% if only time loss injuries were regarded. Head injuries are also reported as a major problem in a study from elite football clubs in Scandinavia (Andersen et al., 2004). In football tournaments assessed using the same methodology, the percentage of head injury varied between 11% and 21% (Fuller et al., 2005). Thus, in football, it has been suggested to give harder regulations and punishment from the referees to reduce the high incidence of head injuries. In team handball, more information about the severity and consequences of head injuries is needed before any decisions about rule regulations can be made. However, the incidence of head injuries should be followed carefully in the future.

The majority of injury (42%) affected the lower extremity, with ankle and knee injuries being the two most common locations of time loss injuries, and ankle sprain the most frequent diagnosis of a time loss injury. This finding is in agreement with results from adolescent and adults handball players of various levels (Nielsen & Yde, 1988; Seil et al., 1997, 1998; Reckling et al., 2003). Recently published studies have shown that it is possible to prevent lower extremity injuries in handball (Petersen et al., 2002; Wedderkopp et al., 2003; Olsen et al., 2005). In a controlled-randomized study of youth handball players, the incidence of lower extremity injuries was significantly reduced by implementing a structured warm-up program to improve running, cutting and landing techniques as well as neuromuscular control, balance and strength (Olsen et al., 2005).

Six ligament ruptures in the knee were reported among female players and one of a male player, which is on average one per tournament. It has been described previously that female handball players have an approximately five times higher risk of incurring a rupture of the anterior cruciate ligament (ACL) than male players (Myklebust et al., 1997, 1998). ACL injuries can be significantly reduced among female handball players by introducing a neuromuscular training program, focusing on balance, landing and planting skills (Myklebust et al., 2003). The same positive results have been found in other team sports such as football (Caraffa et al., 1996; Hewett et al., 1999; Mandelbaum et al., 2005). Based on the high incidence of injuries found in the present study and today's knowledge about prevention, increased focus, time and money should be used in prevention of injuries. Making handball a safer sport should be in the IHF, the national federations, the clubs and the athlete's interest.

In the present study, most injuries (84%) were incurred due to contact with another player. Similar figures were reported by Asembo and Wekesa (1998), Oehlert et al. (2004). Furthermore, during the investigated tournaments almost half of all injuries were caused by foul play as judged by the team physician and the injured player, but only 60% of these injuries were followed by a sanction of the referee. This result stresses the importance of Fair Play as an essential aspect in the prevention of injury. Close cooperation with the referees might help to make handball a safer sport.

As floor type might be an important factor, this variable should be regarded in future studies. Too high or too low a friction can increase the number of injuries, and a higher risk of getting an ACL injury on artificial floors than parquet has previously been shown (Olsen et al., 2003). Thus, it is important to gain more information on the types of floor in relation to the incidence and type of injury so that potential ''high-risk'' floors can be disclosed.

Injuries are a major concern in most team sports. Therefore, prevention should be a priority in all teams. National teams probably have the best physicians and physical therapist available, but it can be questioned whether most of their time is used to treat injuries or prevent re-injuries among the players. With today's knowledge, it is possible to prevent ankle and knee injuries, and this awareness and know-how should be used so that the incidence of injury could be reduced along with the severity and absence from the play (Myklebust et al., 2003; Mandelbaum et al., 2005; Olsen et al., 2005). More attention to the diagnosis and prevention of head injuries is required. Injury surveillance can help to determine needs and possibilities for preventive interventions to make handball an even safer sport.

Perspectives

The incidence of injury during top-level handball tournaments is high compared with amateur players, but similar to the injury rate of football tournaments at the same level. The high number of head and lower extremity injuries is a concern and must be followed carefully in the future. Fair Play is an essential aspect of injury prevention; therefore, close cooperation with the referees is necessary to make handball a safer sport. Injury registration should be continued to survey the injury development and preventive efforts must be a priority in the future.

Key words: team handball, sports injury, incidence rate, international tournaments.

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