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Registration of cruciate ligament injuries in Norwegian top level team handball. A prospective study covering two seasons

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All cruciate ligament injuries in the three upper divisions for men and women (3392 players) in Norwegian team handball in the 1989–90 and 1990–91 seasons were registered. A questionnaire was mailed to all injured players. Ninety-three cruciate ligament injuries were registered; 87 in the anterior cruciate ligament (ACL), and six in the posterior cruciate ligament (PCL). Among women, 1.8% were injured compared with 1.0% of the men. In the first division, the risk of being injured was considerably higher: 4.5% of the players had a cruciate ligament injury. There were 0.97 cruciate ligament injuries per 1000 playing hours in the three divisions taken together. Seventy-five per cent of the injuries occurred during games. Ninety-five per cent involved no contact between players. Activities in which the friction between shoe and floor was significant caused 55% of the injuries. Injuries caused by running into another player contributed to only 5% of the injuries. No significant differences were observed in injury incidence during matches between different types of floors (parquet, Pulastic and other synthetic surfaces).

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Team handball is a high-intensity sport with frequent physical contact between players. In a retrospective study, Strand et al. (1) found a high incidence of anterior cruciate ligament (ACL) injuries in team handball in Norway. An increasing incidence of cruciate ligament injuries has been reported in team handball as well as in other ballsports such as basketball, volleyball and soccer (1–6). In addition to the increased incidence of ACL injuries, some authors have suggested that females in general sustain more injuries than males (5,7,8). The present study was designed to examine cruciate ligament injuries in high-level Norwegian team handball. The specific goal of the study was to evaluate the incidence of such injuries in the three upper divisions, and possible gender differences in the prevalence of these injuries.

Material and methods

Each team in the three upper team handball divisions for men and women (212 teams) participated in the study during the 1989–90 and 1990–91 seasons. Each squad was assumed to consist of 16 players, since this is the number of players in the squad in all international competitions. Thus the total number of players was 3392. The coaches and players received information concerning the study through the Norwegian Handball Federation and direct mailing, and were asked to report all knee injuries to the study group. In addition all clubs were mailed a reminder during the registration period. Information about the injuries was obtained through several channels; from the players themselves, from the coaches, from hospitals, or from the insurance company where all the players in Norway are insured. The primary investigator (GM) kept in close contact with all teams by mail and telephone to ensure that all injuries were reported. All the suspected cruciate ligament injuries were subsequently diagnosed by orthopedic surgeons or physicians specialized in sports medicine. All the ACL injuries were operated on, as well as one of the posterior cruciate ligaments (PCL) injuries. Thus almost all the diagnoses had been verified peroperatively. All the players who were found to have sustained a cruciate ligament injury received a questionnaire. The questionnaire contained questions

regarding gender, age, time of injury, player position and the mechanism of injury.

The number of playing hours was calculated using seven players on each team. Since the matches last 2×30 min this means each match represents 14 player hours. The injury risk per 1000 playing hours was calculated using only the regular league matches. In addition, teams played a few cup and training matches, but these were not included. The number of player hours on the different types of floor material in matches was calculated using the Norwegian Handball Federation's schedule of league matches.

Statistics

The chi-square test was used for comparing differences in the percentage of matches in which one of the players sustained an injury of the cruciate ligament, between men and women and between players of the three different divisions. A *P*-value less than 0.05 was regarded as significant.

Results

All the players sustaining a cruciate ligament injury during the two seasons returned the questionaire; the response rate was therefore 100%. The average age of the injured players in all three divisions was 21.3 (16–34) years for women and 23.8 (16–36) years for men.

Table 1 shows the average age of the injured female and male players in the different divisions. Ninety-three cruciate ligament injuries were observed. Eighty-seven of the injuries occurred in the ACL, six in the PCL. Fifty-nine injuries (63%) occurred in females (54 ACL injuries and five PCL injuries); 34 (37%) were found in males (33 ACL injuries and one PCL injury). All five PCL injuries in women were seen in the first division. The one PCL injury in men was observed in a second division player. On average 1.4% of the players sustained a cruciate ligament injury each season. An identical number of female and male players participate in divisions 1–3. In the females 1.8% of the players suffered a cruciate ligament injury per season, compared with 1.0% of the males. There were 0.97 cruciate ligament injuries per 1000 player hours in all three divisions together.

Table 1. Age (years) of injured players according to sex and division

Gender	Division 1	Division 2	Division 3
Females	21.9 (17–27)	19.4 (17–26)	22.6 (16–34)
Males	22.5 (17–25)	24.0 (20–36)	25.1 (16–36)

Table 2. Injury risk in matches (injury per 1000 playing hours)

Division	Women	Men
1	1.62	0.54
2	1.82	0.84
3	0.72	0.27

Table 3. Cruciate ligament injury per season by division and gender

Division	Gender	Incidence (%)
1	Female	4.5
	Male	2.2
2	Female	2.0
	Male	2.0
3	Female	1.3
	Male	0.6

Table 4. Distribution of injuries in the different player positions (%)

Back players	54
Wing players	30
Line players	5
Goalkeepers	11

Table 2 shows the number of cruciate ligament injuries/1000 player hours sustained during games by gender and division.

Table 3 shows the total incidence of cruciate ligament injuries by gender and division (i.e. for both matches and training sessions.) The incidence was twice as high in females compared with males in the first as well as in the third division. In the second division the incidence was identical among the two sexes.

The consequences of the players' position on the incidence of cruciate ligament injuries is demonstrated in Table 4. The back and wing players sustained 84% of the injuries. Ninety-five per cent of the injuries occurred without any contact with the opposing player. Fifty-five per cent of the injuries occurred in situations where the friction between shoe and floor may have played a considerable role, as in cutting or fake movements. Thirty per cent of the injuries occurred while landing after a jump. Sixteen per cent of the injuries occurred in situations that the player judged to be 'high risk situations'. Eighty-four per cent occurred in situations that the players perceived as 'low risk' as far as injuries were concerned. Seventy-eight per cent of the players were in contact with the ball when injured. Fifty-three per cent were moving at high speed, 33% at slow speed and the remaining 14% were standing still when the injury occurred.

Seventy-five per cent of the injuries occurred during games, and 25% during training sessions. In division 1 half of the injuries occurred during matches, while the corresponding numbers in division 2 and 3 were 73% and 77% respectively. This occurred in spite

Table 5. Floor types and injuries during games and training

	Game	Training
Parquet	21	1
Pulastic	18	13

of the fact that the players spend almost 10–15 times more time training than playing matches.

Fifty-three per cent of the injuries occurred during the first half of the game. Ninety per cent of the injuries occurred while the team was attacking, and only 10% when the team was in defence.

Parquet and Pulastic are the two most commonly used floor materials in Norway. Table 5 shows that the number of cruciate ligament injuries during games were almost identical on the two floors. The number of playing hours on the two surfaces were also almost the same. The number of training hours on the different floors is not known.

The percentage of matches in which one of the players sustained an injury of the cruciate ligament was significantly higher in female (0.77%) compared with male matches (0.31%; $P=0.01$), and in players of the two upper divisions (0.87%) compared with players of the third division (0.35%; $P<0.01$).

Discussion

The results of this study reinforce the high cruciate ligament injury incidence reported previously (1, 2, 3, 5, 6). Furthermore, our report indicates that top-level females injure their cruciate ligament twice as often as males in this particular sport. This has previously been reported in sports like soccer (5, 6, 7, 9), basketball (2, 7, 9) and gymnastics (7).

The response rate in the present investigation was very high: 100%. Only players with a known cruciate ligament injury were given the questionnaire, and there may have been players with unrecognized cruciate ligament injuries that were not included. However, the medical staff for the teams in division 1 and 2 should be able to pick up these serious injuries. In the third division the teams are spread out all over the country and generally have a less active medical support. There may therefore have been some unrecognized injuries in this division. However, we believe that very few remained undetected since our investigation received broad press coverage all over the country, making coaches, players as well as local physicians more aware of these injuries.

The cruciate ligament injury rate was higher in the upper two divisions. We feel comfortable that the reported injuries represent the true number in divisions 1 and 2, but, for reasons stated above, are somewhat more uncertain about the numbers in division 3. However, even with this uncertainty the study suggests two- to fourfold more injuries in division 1 compared with the lower divisions.

The observed number of cruciate ligament injuries /1000 player hours was higher than those previously published (5, 7, 9). The number was higher in the second division than in the first division for both sexes. The overall incidence of cruciate ligament injuries in division 1 was much higher in the females and higher in the males than in division 2. More players were injured during training in division 1. This indicates that they train more, and with a higher intensity.

The injury risk was much higher during games than during training. Seventy-five per cent of the cruciate ligament injuries occurred during games. Similar data have previously been published for soccer (6) and volleyball (3). This is somewhat puzzling, since the players spend about 10–15 times more time training as playing matches. The reason may be that the intensity is much higher during games than during training. The relatively high incidence of injuries in training in division 1 could be explained by the fact that in top level teams the intensity of the training is higher than in divisions 2 and 3.

There were almost as many injuries during the first as during the second half of the games. Fatigue, therefore, does not seem to be a major factor in the etiology of these injuries. However, it should be noted that we did not ask the players how long they had actually played before they were injured.

The etiology of the high rate of cruciate ligament injuries in females compared to males is not clear. Numerous hypotheses have been offered: differences in ligament laxity (10); bony anatomy (11–13); muscle strength (14); proprioception and skill level (10) have all been suggested in the literature. However, few hard data exist regarding the gender-specific mechanism of cruciate ligament injuries. Muscular weakness has been reviewed with no conclusive evidence pointing to a gender difference (15).

It should be noted that contact with other players does not seem to be important. This has also been observed in basketball (9, 16). Supporting this is our finding that the majority of the injuries occurred in situations that were not perceived by the players as dangerous.

However, it has been reported (17) that high speed and many violent contacts in a small playing area are shown to be associated with increasing injury risk. Thus, even though the true contacts are not the usual reason for ACL injuries, the problem behind this may be that the players move against each other with high speed in a limited area.

Most injuries seemed to occur in situations where the friction between shoe and floor is of importance. Thus 90% of the injuries were found to occur when

the teams were attacking; a part of the game in which most of the fake movements are performed. Likewise, the observation that the back and wing players sustained 84% of the injuries supports this notion, since these players perform most of the fake movements. However, identical movements are carried out by male handball players with half the incidence of cruciate ligament injuries.

Conditioning and experience have been suggested as possible variables in the multifactorial mechanism associated with an increased cruciate ligament injury rate in female team handball players. However, the elite female handball players in Norway (division 1) train at least as hard as the men, and they have as many years of experience with handball. These factors therefore seem unlikely to be of great importance. However, even though they train equally hard as the men, women may still be weaker and less coordinated than their male counterparts.

Another possible etiological factor implicated as a reason for cruciate ligament failure has been the anatomy of the intercondylar notch (ICN); i.e. a narrow notch shape and size has been suggested as a contributing factor to cruciate ligament injuries. However, no conclusive evidence can be drawn from the literature so far regarding gender variations in relation to ICN indices. In one study (11) no differences were observed; while other investigators have found a more narrow notch in females compared with males, and conclude that this may mean that females have a higher risk for ACL injury (12, 13). Due to their less muscular development and their lower extremity alignment differences, females probably rely more than men on the ACL and less on hamstring control. This may result in a higher incidence of cruciate ligament injuries.

In conclusion, the very high incidence of cruciate ligament injuries in team handball suggested by retrospective studies is supported by the present study. Females have twice the risk as males for such injuries. The risk is also higher in the higher divisions. The majority of injuries occur without contact with the opposing player in situations where the friction between the foot and the floor is of importance.

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