

# ACL PREVENTION IN FEMALE HANDBALL

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Knowledge regarding ACL injuries in handball has improved substantially in the last 10 to 15 years. We know more about who is injured, how the injury happens and most importantly, how ACL injuries can be prevented. We now know that female players can reduce their risk of an ACL injury by 50%! This is the most important message in the following paper, which will describe how players can achieve this 50% reduction and why it is important, as well as who is at risk of injury.

## WHO GETS INJURED?

A key question has been: are female players at greater risk than males? The first study on this was published in 1990<sup>1</sup>. The ACL injury incidence was highest among elite female players with 0.82 ACL injuries per 1000 playing hours compared to males with 0.31 injuries per 1000 playing hours<sup>1</sup>. This gender difference has later been confirmed by Myklebust et al<sup>2,3</sup>. The highest

ACL incidence reported is among elite female handball players in Norway with 2.29 ACL injuries per 1000 match hours<sup>4</sup>.

Most ACL injuries occur in players in their late teens and early 20s. Data from the national ACL registries in Scandinavia also show an increase in ACL injuries among young female players (Lars Engebretsen, personal communication).

## MATCH VS TRAINING & LEVEL OF PLAY

There is no doubt that the risk of getting an ACL injury is much higher in matches compared to training, perhaps as much as 30 times higher<sup>5</sup>. The exact reasons for this are not known, although it's probably safe to assume that it is related to the intensity of play.

Playing at the top level increases the risk of ACL injury. Strand<sup>1</sup> reported in 1990 that female players in the top three divisions have a higher ACL injury incidence than players playing at lower levels. This is

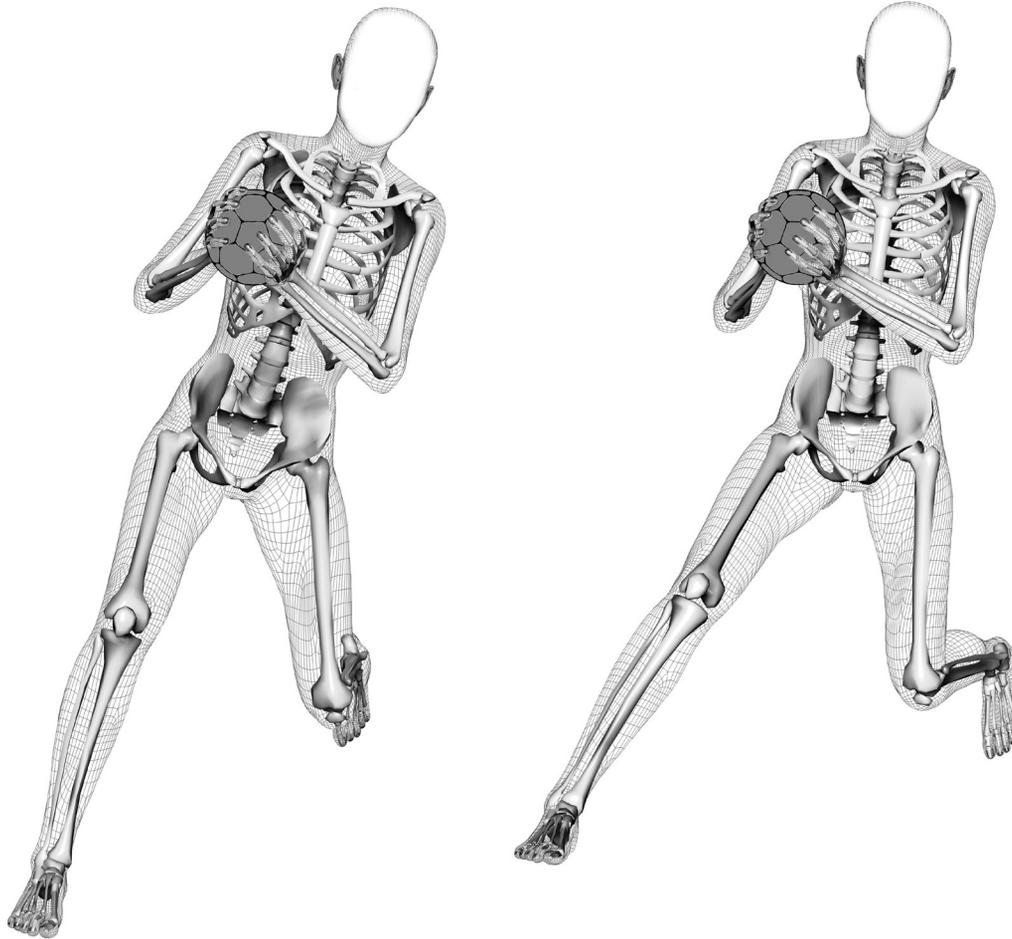
confirmed by Myklebust et al, who found that the highest incidence of ACL injuries in handball was among female elite players<sup>2-4</sup>.

## PLAYING POSITION

Are some playing positions at greater risk than others? This has been explored in several studies. The standard line-up in handball is three back players (43% of the team), two wing players (29%), 1 line player (14%) and 1 goalie (14%). When summarising data from three different studies reporting the playing position of ACL-injured players, the distribution is as follows:

- 112 (60%) were back players,
- 52 (28%) were wing players,
- 9 (4%) were line players and
- 15 (8%) were goalkeepers.

This means that the relative risk of an ACL injury appears to be higher among back players and lower among goalies and line players. Another trend is that it seems that at the elite level, the proportion of injured



**Figure 1:** A more narrow cutting technique (preferred).

**Figure 2:** A wide cutting technique (higher ACL injury risk).

back players is even higher. One likely explanation for this tendency is that back players perform at-risk movements such as planting, cutting and jumping more often<sup>2-4</sup>.

#### INJURY MECHANISMS

Most ACL injuries in handball are non-contact in nature; approximately 90% of injuries occur without contact with an opponent<sup>2,3</sup>. Of the two main injury mechanisms, approximately 90% of injuries occur when the player performs a cutting or turning movement or in a one-leg landing after a jump. Even if there is no direct player contact to the knee, some perturbation by opponent interaction can sometimes be observed before the injury.

The mechanisms for non-contact ACL injuries have been widely discussed. What seems clear from several studies from various team sports is that knee valgus (high knee abduction moments), where the knee collapses inwards into a 'knock-knee' position, is an important factor.

In a recently published study, Kristianslund et al<sup>6</sup> analysed the cutting

technique among 123 of Norway's best female handball players. They wanted to identify the technique that resulted in the lowest knee abduction moment. High knee abduction moments or valgus moments, may increase the risk of ACL injuries, and training of techniques that reduce knee abduction moments is likely beneficial for reducing the ACL injury risk. The players performed sidestep cuts in a biomechanics lab which enabled accurate descriptions of joint movements and loading. The technique was described with 12 factors including knee valgus, hip abduction, toe landing, approach speed, cutting angle and cut width. The results showed that sidestep cutting technique explained 62% of the variance in knee abduction moments. Sidestep cuts performed with high knee valgus, heel landing and wide stance resulted in higher knee abduction moments<sup>6</sup>. This study confirms that technique factors are strongly related to lower knee abduction moments. This high-loading technique is similar to descriptions of the injury mechanism. When analysing

cutting injury situations the injury often occurs with a valgus collapse in wide cuts with a heel landing.

This study confirms that the frequently used catch phrase in prevention programmes, "keeping the knee-over-the-toes position", seems justifiable and should continue to be used. In addition, it also emphasises the importance of teaching young players to perform a narrower cut. Technique training that reduces the knee valgus moment should include a focus on toe landings, a knee-over-toe position and narrow cuts. Figures 1 and 2 illustrate a cutting movement with two different leg positions, one with a more narrow cut (preferred) and one with a wide cut (higher ACL risk).

#### RISK FACTORS

The gender difference is apparent when analysing ACL injury risk in handball. However, the reasons for the obvious gender gap in the risk of ACL injury are not completely clear. Various researchers have suggested differences in anatomy, hormonal

## KEY COMPONENTS OF SUCCESSFUL ACL INJURY PREVENTION PROGRAMME

- *Warm-up programme, including a combination of balance/co-ordination, technique, lower limb and core strength, plyometric and agility exercises.*
- *Focus on technique:*
  - *A more narrow cutting technique including toe landing.*
  - *Two-leg landings.*
  - *Proper balance with hip, knee and toe in line.*
- *Include a variety of exercises with a progression from easy to more difficult to continually pose a challenge to athletes (important for motivation!).*
- *Include exercises in pairs to make training more fun, but also maximise movement quality.*
- *Include ball exercises when basic exercises are well established.*

and neuromuscular function as potential reasons for the higher injury risk in women than in men. To date, however, there is little evidence linking all these potential intrinsic risk factors to non-contact ACL injuries, and a great deal of controversy exists on the relative importance of the different factors.

A key external risk identified is high friction between shoes and the playing surface. Handball is played on different floor types with varying friction characteristics and shock absorbing ability. Floors are usually of two types: parquet (wooden floor) or artificial floors. One study has shown that the risk of ACL injury is 2.4× greater when competing on artificial floors (with an increased coefficient of friction) compared with wooden floors<sup>7,8</sup>. Therefore, it seems reasonable to suggest that players should have at least two different pairs of shoes, one more 'slippery' pair suitable for high-friction floors and one pair with more traction for slippery floors.

### PREVENTION

In a study by Myklebust et al<sup>4</sup>, a five-phase neuromuscular training programme was tried out among approximately 1,000 female players in the top three divisions in Norwegian handball. The programme consisted of three different balance and strength exercises focusing on neuromuscular control and cutting and landing skills. The players were encouraged to be focused and conscious of the quality of their movements, with emphasis given to core stability and hip and knee position in relation to the foot (the 'knee-over-toe' position). The intervention resulted in a substantial reduction in the risk of ACL

injuries from the control season to the second intervention season among the elite players who completed the programme<sup>4</sup>. Figure 3 (available online) gives a presentation of the exercises that the players used in the intervention.

In the study by Petersen et al<sup>9</sup>, 10 female handball teams (134 players) took part in a prevention programme to prevent ankle and ACL injuries. The programme consisted of:

1. information about injury mechanism,
2. balance-board exercises,
3. jump training,

while 10 control teams (142 players) were instructed to train as usual.

They followed the teams over one season and achieved a non-significant reduction of ACL injuries with 5 vs 1 ACL injuries in the control group compared to the intervention group<sup>9</sup>.

A high quality study design was used in the first randomised controlled trial in handball by Olsen et al<sup>10</sup> among youth female and male players. They showed that a structured warm-up programme including running exercises with and without ball, technique training focusing on safe cutting movements, two-feet landings after jump shots, balance training and strength and power exercises gave a highly significant reduction (50%) in the rate of acute lower extremity injuries among players in the intervention group. In this study the teams were highly compliant with the programme – 87% of the teams performed the programme as intended. In addition, the sample size was high enough to detect a difference between the intervention and the control group.

A video presentation of the prevention programme of the studies of Olsen et al and Myklebust et al are available at [www.skadefri.no](http://www.skadefri.no).

Despite the relatively sparse number of studies, we can conclude that it is possible to prevent severe knee injuries in handball – we can even reduce the risk of ACL injuries by 50%! Prevention studies from other team sports support this conclusion<sup>11-13</sup>.

### HOW CAN WE KEEP THE ACL NUMBERS LOW?

Studies from handball have shown that success in ACL prevention in the short-term is possible. However, that an intervention is efficacious in a controlled trial does not mean that it will be widely adopted and sustained and have an impact on handball players worldwide. Finch<sup>14</sup> outlined the Translating Research into Injury Prevention Practice (TRIPP) framework, emphasising that only research that can and will be adopted by participants, coaches and sporting bodies will succeed in the long run<sup>14</sup>.

After the ACL prevention study in Norway was finished, the ACL numbers in the three top level divisions was surveyed for 10 years<sup>15</sup>. The ACL numbers increased in the first years after the intervention had been terminated. From interviews with injured players, the authors realised that the promising findings from the ACL Injury Prevention Study, which were published in 2003, did not result in the programme being implemented as a regular part of training by coaches or players. The teams and players did not continue doing the prevention programme after the research study was finished at the end of the 2000-2001 season.

Several measures were made the following years to change this negative trend. To increase knowledge and improve attitudes among coaches and managers a series of regional coach seminars were organised free of charge in 2005. Seminars were held in Norway's five largest cities and handball coaches, managers and some players attended. In addition, the prevention study among youth handball players by Olsen et al<sup>10</sup> was published and received extensive media attention via newspapers, television and an article in the Norwegian Handball Magazine which was received by

every member of the Norwegian Handball Federation.

As shown in Figure 4, there was a substantial reduction in the ACL injury rate after the information campaign from 2005-2006 and onwards. These low numbers have remained low in the subsequent seasons. One important contribution to keep the ACL numbers low was a new website ([www.skadefri.no](http://www.skadefri.no)), launched by the Oslo Sports Trauma Research Center in May 2008. The website is designed to provide information on injury prevention programmes in a format targeting coaches and athletes, and includes videos of exercises from various prevention programmes<sup>15</sup>.

#### COACH AS A KEY PARTNER

Winning and performance are the key factors for coaches and players. Injured players will not improve their own or the team's performance. Coach education is a key factor. Well-trained coaches will be able to deliver a new exercise programme in the correct way. Knowledge of sports injuries, injury prevention, attitudes and beliefs around the importance of injury prevention training is quite variable among coaches. Without doubt, injury prevention should be mandatory as part of coach education and certification at all levels.

#### HOW CAN HANDBALL BECOME A SAFER SPORT?

This article has shown that it is possible to prevent ACL injuries by using neuromuscular training and a structured warm-up programme. In addition, there are other aspects that should be kept in mind when trying to reduce the ACL injury numbers.

The risk of suffering a serious knee injury may increase during championships when the best players are exposed to an abnormally high number of matches during a short time period. In planning championships, Olympic Games and other tournaments, it is important to allow an adequate number of days for the athlete to recover. For young players who participate at a high level there is a clear tendency for participation on many teams and to compete at different age levels. This increases the number of matches/competition and reduces the time

**injury prevention should be a mandatory part of coach certification**

they have available for rest and training. Playing matches is a high risk situation for ACL injuries. Every handball federation should be aware of this and try to protect young athletes from over-participation in sports.

As noted above, players should have two different pair of shoes: one for high- and one for low-friction floors. In addition, we must also keep in mind that cleaning and maintenance routines influence floor friction, regardless of floor type.

When children start playing handball, help them to develop good warm-up habits, fair play attitudes and teach them a safe cutting and landing technique. Why not use the best coaches on young athletes?

#### CONCLUSION

It is possible to prevent ACL injuries! We know that exercise programmes need to include a combination of balance/co-ordination, strength, plyometric and technique exercises. These exercises should therefore be included in the warm-up routine.

Future studies should focus on a better understanding of ACL injury risk factors and mechanisms. This knowledge can help us to optimise current injury prevention programmes. My best recommendation is to establish warm-up routines and put the existing knowledge of ACL injury prevention into practice.

Athletes, coaches and club leaders should know that ACL prevention works! Use it!

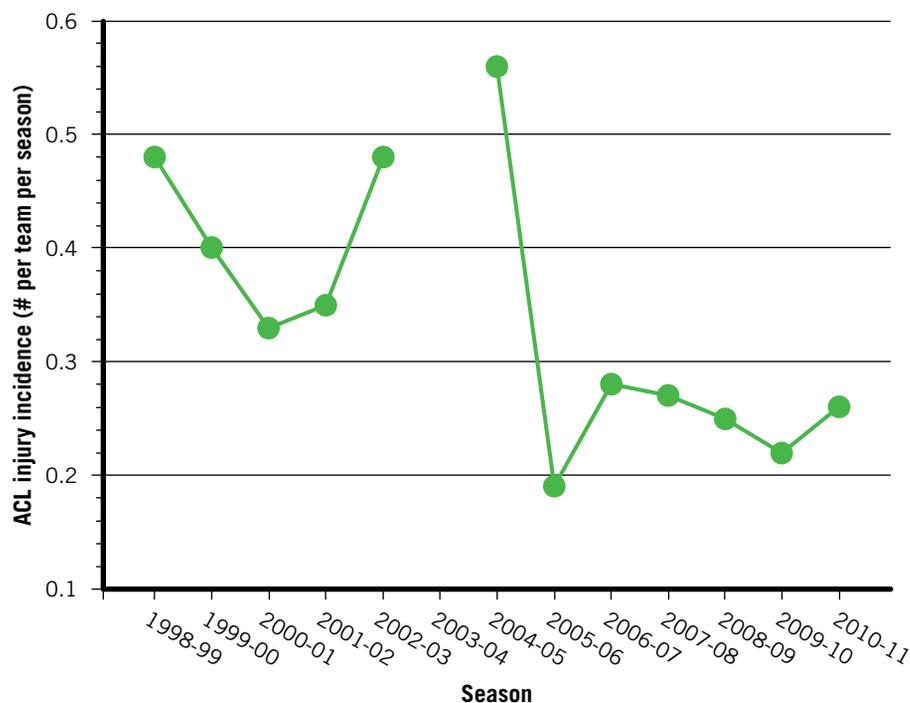


Figure 4: ACL injury incidence (# per team per season).

## PREVENTION OF ACL INJURIES IN TEAM SPORTS

A 5-phase 15 minute programme with 3 different balance exercises focusing on neuromuscular control and planting/landing skills was developed and introduced to female elite handball players. Injury risk was significantly reduced for those players who highly complied with the exercises<sup>4</sup>. Balance exercises are usually done on a balance board or on an unstable balance pad, with the knees and hips slightly flexed. Ball or partner exercises may also be included to make training more challenging and fun. While proper hip and knee control is always emphasised, the exercises for balance, jumping and

landing can be adjusted to suit all sports that are characterised by cutting and landing movements. These exercises can also be incorporated into a warm-up programme. Though this programme seems to focus much on balance, there are also strength elements included, such as two- and one-leg squats. Remember, always have proper hip-knee-toe control. During an initial training period of at least 5 weeks, the exercise should be done a minimum of 3× per week, training for 10 to 15 minutes per session. Maintenance training 1× or 2× a week should continue throughout the competitive season.

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