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High prevalence of shoulder pain among elite Norwegian female handball players

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Clinical experience indicates that a substantial number of handball players may suffer from shoulder pain, but they continue to play despite having shoulder pain problems. The aim of this study was to evaluate the prevalence and consequences of shoulder pain problems among Norwegian female elite handball players. In the preseason of the 2007–2008 season, 179 players from all 12 teams of the Norwegian elite league went through the following tests: internal and external shoulder range of motion, apprehension, relocation test, and shooting velocity. All players completed the Fahlström questionnaire and, for players with current pain, the Western Ontario shoulder instability index questionnaire. Sixty-five (36%) players reported shoulder pain on the test day, and 40 (22%) players reported previous shoulder pain. Two thirds of the players with pain reported a gradual onset. For players with current or previous pain, 22 (36%) and 14 (36%) had missed match play, and 43 (68%) and 28 (76%) reported changing their training habits. A positive apprehension and relocation test was found among 51 (29%) of the players. In conclusion, a high proportion of female elite handball players experience shoulder pain and problems and have an unstable shoulder.

Handball is a tough contact sport with many collisions between opponents (Vlak & Pivalica, 2004). High speed combined with rapid direction changes, cutting movements, and frequent jumps result in high loads on the lower extremities. In addition, the large numbers of throws and passes, as well as hard body tackles, in many cases directly to the shoulder, make the shoulder region vulnerable for both acute and overuse injuries (Wilk et al., 2002; Kelly et al., 2004; Vlak & Pivalica, 2004).

Most epidemiological studies in handball have targeted acute injuries in general and acute injuries to the lower extremity in particular (Myklebust et al., 1997, 1998, 2003; Wedderkopp et al., 2003; Olsen et al., 2006). However, little is known about upper extremity injuries, and the magnitude of overuse problems in the handball shoulder is unknown. Overuse problems can be perceived as pain, shoulder instability, and scapular dysfunction, which in many cases will influence an athlete's performance. Several studies on baseball pitchers have shown that the throwing mechanism places considerable stress on the glenohumeral joint (Dillman et al., 1993; Fleisig et al., 1995). As the throwing motion in handball is quite similar to that seen in pitching, it may be expected that the shoulder capsule, ligaments, and muscles are exposed to repetitive stress and subsequent injuries in much the same way as other throwing sports.

The only investigation to date providing data on the prevalence of shoulder pain among handball players is the study by Gohlke et al. (1993) on German elite handball, basketball, volleyball, and water polo players. They found that 40% of the 24 handball players included lost time from training and competition during the previous 6 months because of shoulder pain (Gohlke et al., 1993; Bahr, 2009). A 1-year prospective study among 16 men's senior handball teams identified the shoulder as the most common site for overuse symptoms (Seil et al., 1998). In other sports, shoulder pain problems have been reported to affect as many as 52% among world-class and recreational badminton players (Fahlström et al., 2006; Fahlström & Söderman, 2007) and between 10–57% among professional beach volleyball players (Bahr & Reeser, 2003).

Following the four-stage model of van Mechelen et al. (1992) describing the magnitude and severity of the problem is the first step in the development of effective injury prevention strategies. Therefore, the aim of this cross-sectional study was to describe the prevalence and consequences of painful shoulder conditions among elite female handball players.

Materials and methods

This study is based on an ongoing cohort study aimed at investigating risk factors for noncontact anterior cruciate ligament (ACL) injuries among Norwegian elite female team sport players. All of the 12 female handball teams (approximately 180 players) of the Norwegian elite league, as well as the players on the Norwegian national team playing elsewhere were invited to take part in the study.

A comprehensive questionnaire distributed as part of the cohort study included descriptive information such as player age, height, weight, and exposure to handball. For the shoulder project, players were asked to complete specific questionnaires on present and previous shoulder pain described below.

Pilot testing was performed on approximately 30 lower division male and female team players in May 2007. The players included in the cohort were tested in June 2007 (early preseason) at the Norwegian School of Sport Sciences, and a total of 162 players from 12 teams were available for testing (90%). In addition, 17 players in the national team squad playing for foreign clubs were tested. A player was entered into the study if she was registered on the A-team roster of a handball team participating in the Norwegian elite league season 2007–2008 or was a member of the national team.

The study was approved by the Regional Committee for Medical Research Ethics, South-Eastern Norway Regional Health Authority, Norway. All players provided their written consent.

Self-reported shoulder pain

Fahlström questionnaire

We modified a questionnaire used in Swedish badminton (Fahlström et al., 2006; Fahlström & Söderman, 2007) by translating the Swedish form to Norwegian and by adapting the questions to handball. This form included questions on the perceived level of shoulder pain in relation to handball training or matches, whether or not the athlete had experienced pain at the test day and/or whether the athletes had experienced shoulder pain previously. The modified Fahlström form was pilot tested on 10 recreational handball players (on average, 10 years of exposure to organized handball play), and minor changes were applied before the final version was accepted.

For most questions, entry was required on a dichotomous scale (yes/no) or a Likert scale. The intensity of pain was registered on a visual analogue scale (VAS; 100 mm) ranging from 0 to 100, with 0 expressing no pain and 100 expressing the opposite, that is, extreme pain. Based on our clinical experience, we defined a cutoff value of 40 (out of 100) as substantial pain.

Western Ontario shoulder instability index (WOSI) questionnaire

Those players who reported shoulder pain on the day of testing were also asked to complete the WOSI questionnaire (Kirkley et al., 1998). WOSI is a validated quality-of-life measurement tool developed for patients with shoulder instability. The form has 21 items representing four domains: physical symptoms, sport/recreation/work, lifestyle, and emotions. The first domain, physical symptoms, contains 10 items. Both sports/recreation/work and lifestyle contain four items, and the remaining domain emotions contain three items. Each item has a possible score from 0 to 100 (100 mm VAS), and the scores are added to give a total score from 0 to 2100. The best score possible is 0, meaning no shoulder problem, and the worst possible score is 2100, which implies that the person has extremely reduced shoulder-related quality of life (Kirkley et al., 1998). The results from WOSI can be presented in two forms, as a score value (points) or converted to a percentage of normal value by the use of a formula (Kirkley et al., 1998).

Clinical examinations

All clinical shoulder tests were carried out by two experienced clinicians: an orthopedic surgeon and a physical therapist. Each had clear tasks during the testing procedure, such that all tests were performed by the same person. The tests included examination of glenohumeral internal and external range of motion (ROM), and instability tests (apprehension and relocation test) on both shoulders. Finally, shooting velocity was measured by a radar gun. All shoulder tests were performed in the same order for all the players.

Glenohumeral internal rotation (IR) and external rotation (ER) test

The passive range of glenohumeral IR and ER was measured using the protocol described by Wilk et al. (2011). The player was supine with their shoulder in 90° of abduction and 10° of horizontal adduction (in the plane of the scapula) (Figs 1 and 2). One examiner was responsible for stabilizing the scapular and for guiding the player's shoulder into full rotation while a second examiner measured the ROM using a standard goniometer. The total rotational motion (TRM) was calculated for each shoulder by adding the IR and ER values.

Fig. 1. Internal and external rotation measured by a goniometer.

Fig. 2. External rotation measured by a goniometer.

Instability tests – apprehension and relocation tests (Jobe et al., 1989)

In the supine position on a bench, the shoulder was placed in passively maximal ER and horizontal abduction. The test was considered positive if the player experienced pain or tried to withdraw her arm. The relocation test was performed in the same position, and the investigator performed manually a dorsal glide on the humeral head in the apprehension position. The test was considered positive if there was pain relief and the arm could be moved further into ER.

Shooting velocity

The players had to perform a 10-min shoulder warm-up including running and throwing the ball before the maximal shooting velocity test started. The velocity was measured with a hand-held radar gun (Stalker Digital Sports Radar, Applied Concepts Inc., Plano, Texas, USA). The investigator was standing behind the goal, and the players were asked to hit in the middle of the goal. The same person performed all the speed measurements. Shooting velocity was measured from 7 m to 9 m from the handball goal. After two trial shots, three maximum shots were performed and measured. For the 9 m shot, players were allowed to use a three-step running approach before shooting from the floor, the normal technique for a distance shot in handball. The 7 m shot was performed standing still as a penalty shot is normally performed.

Statistics

Descriptive data, as player characteristics and history, internal and external shoulder ROM and pain intensity, are presented as mean values with their standard deviations, while proportions of self-reported present and previous pain are presented as absolute numbers with percentages. Comparisons of categorical variables were analyzed using a chi-square test or Fisher's exact test for small numbers. Data were tested for normal distribution, and parametric statistics were used. Side-to-side differences in ROM between dominant and nondominant arms were analyzed using paired *t*-test, while differences in shooting velocity between players with current, previous, and without shoulder pain were assessed using analysis of variance and Bonferroni post-hoc analyses. Group differences in age and shoulder ROM between players with a positive vs a negative apprehension/relocation test were assessed by unpaired *t*-tests. The level of significance was chosen as $\alpha = 0.05$, and all tests were two-tailed.

Results

A total of 179 players (22 ± 4.0 years, 173.5 ± 6.5 cm height, 68.8 ± 7.0 kg weight) were included in the study. They were predominantly right-handed (148, 83%) and represented mostly back (86, 48%) and wing players (45, 25%). A total of 21 goalkeepers (12%) and 27 line players (15%) completed the study population. They started playing at the highest playing level in Norway at an age of 18.6 ± 2.2 years and had until the testing been involved in elite level play for 3.9 ± 6.6 years.

The players reported 10.3 ± 2.0 h of exposure to handball per week during the competitive season. In addition, they completed 3.3 ± 1.3 h of strength training and 2.2 ± 1.4 h of endurance training. In the preseason period, the distribution of playing and training exposure changed to 6.4 ± 3.0 h of handball play, 4.7 ± 1.8 h of strength training, and 4.0 ± 2.1 h of endurance activities.

Self-reported shoulder pain (Fahlström questionnaire)

In the study population of 179 players, 65 players (36%) reported having current shoulder pain, 40 players (22%) reported to have had shoulder pain previously during their handball career, while 74 players (41%) reported never having had shoulder pain. Players with previous pain were significantly older than players without shoulder pain (23.8 ± 4.5 vs 21.6 ± 4.1, $P = 0.01$).

Almost all players with current and/or previous shoulder pain (100 of 105, 95%), suffered from shoulder pain in their throwing (dominant) arm, five players had pain in the opposite (nondominant) shoulder only, while 10 players reported bilateral pain.

Two thirds of the players affected reported a gradual onset (Table 1). Table 1 also shows a high proportion of players reporting that activities of daily living as well as sports activities were affected by their painful shoulder. There was no relationship between the onset of pain (gradual or sudden) and the total training or match load.

Of players reporting current shoulder pain ($n = 65$), 11 players (30.1%) had suffered from pain for the last 4 weeks before testing, six players (16.7%) suffered from pain for 5–26 weeks, seven players (19.4%) suffered from pain for 27–52 weeks, and a total of 12 players (33.3%) had been affected by shoulder pain for more than 1 year. Information on the duration of shoulder pain was missing in four cases. Players with current pain ($n = 56$) reported a VAS of 56 ± 16 (nine missing). A total of 45 players (80% of players with current problems) scored above the self-defined cutoff value of 40, reflecting substantial pain.

A total of 34 players (52.3% of players with current problems) reported having shoulder pain while playing handball; another 10 players (15.4%) reported pain after handball exposure, 16 players (24.6%) had intermittent pain regardless of exposure, and 1 player (1.5%) had constant pain (four players missing).

Table 1. Characteristics of shoulder pain for players with current shoulder pain ($n = 65$) or pain previously in their handball career ($n = 40$)

	Current pain $n = 65$ (%)*	Previous pain $n = 40$ (%)*
Onset of pain		
Sudden	15 (25.0)	17 (44.7)
Gradual	45 (75.0)	21 (55.3)†
Changed training habits	43 (68.3)	28 (75.7)
Could not participate in match play	22 (35.5)	14 (35.9)
Affected ADL activities	27 (42.2)	18 (47.4)
Resulted in medical assistance	42 (70.0)	29 (80.1)

*Valid percent values.

†$P = 0.049$ between players' onset of pain (sudden or gradual).

ADL, activities of daily living.

Table 2. Player position for players with pain at present ($n = 40$), with previous shoulder pain ($n = 40$), with pain and present and previously ($n = 25$), and without shoulder pain ($n = 74$)

	Current pain *n*	Pain previously *n*	Never had pain *n*	Total *n*
Goalkeeper	4	3	14	21
Back	32	21	33	86
Wing	22	7	16	45
Line	7	9	11	27
Total	65	40	74	179

Table 3. WOSI score in total and for the four domains for 58 female elite handball players with shoulder pain at present (mean, SD) and percent of reference values

Domains	Mean (SD)	%
Physical symptoms (out of 1000)	371 (164)	63
Sport/recreation/work (out of 400)	108 (77)	73
Lifestyle (out of 400)	58 (56)	86
Emotions (out of 300)	128 (80)	57
WOSI total score (out of 2100)	665 (312)	68

SD, standard deviation; WOSI, Western Ontario shoulder instability index.

With respect to player position, 7 of 21 goalkeepers (33%) reported current and/or previous pain compared with 53 of 86 back players (62%, $P = 0.019$ vs goalkeepers), 29 of 45 wing players (64%, $P = 0.018$ vs goalkeepers), and 16 of 27 line players (59%, $P = 0.07$ vs goalkeepers) (Table 2).

Self-reported shoulder pain (WOSI questionnaire)

The WOSI questionnaire was completed by 58 of 65 players who suffered from current shoulder pain (89.2%). The total WOSI score for this group was 665 out of 2100, 68% of the reference value. Within the four domains, the players scored lowest on "emotions" (Table 3).

ROM

Significant differences were observed between players' dominant and nondominant shoulders for both IR and ER throughout the entire cohort (Table 4). However, no differences were observed between groups of players with current pain, previous pain, or no history of pain for IR or ER. There were no differences in TRM between dominant and nondominant shoulders in any groups.

Shoulder instability, pain, and ROM

Among all participating players, 28.5% (51 out of 179) had a positive apprehension and relocation test. Among players with no history of pain, 4 of 74 (5.4%) had a positive apprehension and relocation test, while there were 39 of 65 (60.0%, $P < 0.001$ vs players with no pain) with positive tests among players with current pain and 8 of 40 (20.0%) among players with a previous history of pain ($P = 0.015$ vs players with no pain). However, there were no group differences in shoulder ROM between players with a positive vs a negative apprehension/relocation test, either between players' dominant and nondominant shoulder and shoulder instability.

Table 4. Mean (SD) internal, external, and total shoulder range of motion (°) for players with current pain ($n = 40$), with previous shoulder pain ($n = 40$), and with no shoulder pain ($n = 74$)

	Current pain $n = 65$	Previous pain $n = 40$	No pain $n = 74$
Range of motion			
Internal rotation			
Dominant arm	43.6 (7.1)*	45.0 (8.2)†	44.5 (8.4)†
Nondominant arm	48.2 (6.7)	49.0 (6.3)	47.8 (8.8)
External rotation			
Dominant arm	103.6 (8.9)‡	105.0 (8.1)*	106.1 (9.5)*
Nondominant arm	101.5 (9.2)	100.1 (7.4)	102.7 (9.0)
Total Rotational Motion			
Dominant arm	147.2 (10.1)	150.0 (9.6)	150.6 (10.9)
Nondominant arm	149.7 (9.2)	149.0 (9.3)	150.5 (10.4)

*$P < 0.001$;
†$P = 0.001$;
‡$P = 0.008$ between dominant and nondominant arm.
SD, standard deviation.

Table 5. Mean (SD) shooting velocity (km/h) for players with current pain ($n = 54$), with previous shoulder pain ($n = 39$), and with no shoulder pain ($n = 74$)

	Current pain $n = 54$ (83%)	Previous pain $n = 39$ (98%)	No pain $n = 74$ (100%)
Shooting distance			
7 m	74.6 (6.0)	75.4 (6.1)	74.9 (4.6)
9 m	80.8 (6.1)	82.9 (5.4)	82.2 (5.1)

SD, standard deviation.

Shooting velocity

A total of 12 (7%) players did not perform the shooting velocity testing because of shoulder pain on the test day. Among the remaining players, we observed no significant differences in shooting velocity between players with and without previous and/or current shoulder pain, neither from the 7-m nor the 9-m distance (Table 5).

Discussion

The main finding of this investigation was that shoulder pain is a significant problem among female Norwegian top-level handball players; more than half of the 179

players (57%) were affected by previous or current shoulder pain, and players with shoulder pain on the day of testing reported having had pain for at least 6 months. We also found that 29% of all players had a positive apprehension and relocation test, 60% among players with present pain. However, we observed no differences between players with or without current or previous shoulder pain in shoulder ROM or shooting velocity.

The investigation by Gohlke et al. (1993) from German men's handball was the first study to recognize shoulder pain as a substantial problem in handball (Gohlke et al., 1993). They showed that 40% of the players lost time from handball training and competition because of shoulder problems during the previous 6 months. A limitation of that study was that only 24 players were included. Our study, the first on female handball players, showed that a majority of players had been affected. As the first step in van Mechelen's et al. (1992) injury prevention sequence, the present results confirm what many experienced clinicians working with handball players have suspected, namely that shoulder pain represents a substantial problem.

Our investigation was carried out during the preseason period, when there is more focus on general conditioning and relatively less exposure to shoulder stress and match play. Therefore, it seems reasonable to assume that the prevalence of shoulder pain during the competitive season is even higher. Nevertheless, it should be noted that shoulder pain had affected handball participation significantly; 68.3% of the players changed their training habits because of pain, and 52.3% reported pain during match play. "A new study analyzing the shoulder pain problems among handball players should be performed during the season when the exposure to handball matches is much higher than in the pre-season."

One strength of the current study is the cohort size. Moreover, as the study population was recruited for a cohort study aimed at investigating risk factors for non-contact ACL injuries, it seems unlikely that there would be any recruitment bias related to shoulder status. Another strength of this study is the high recruitment rate (90% of all players on the teams invited). We invited all female elite handball players available for the top league play in the season 2007–2008, and all teams, including the National Coach and the Norwegian Handball Federation strongly, supported the project. The only players not available for testing were those who were injured at the time of testing (mainly knee and ankle injuries) or unavailable for other reasons. Therefore, we feel comfortable with having tested a representative population of female top-level players with a similar exposure to competitive play and shoulder activities.

Our results are in line with the results from two studies from badminton (Fahlström et al., 2006; Fahlström & Söderman, 2007). They examined both world-class and recreational male and female players, reporting a 52% prevalence of current or previous shoulder pain problems, but only 16% reported that this had affected their training or competition. There were no sex differences (Fahlström et al., 2006; Fahlström & Söderman, 2007). Badminton and handball are characterized by repetitive overhead shoulder motion where the shoulder is maximally loaded in abduction and ER during throwing and shooting. However, in contrast to badminton, handball is a team sport with frequent contact and even collisions between opponents, as well as falls in both the defensive and the attacking phases of the game. The attacking player's throwing arm is also regularly hooked from behind by an opponent, even if this is a red-card offense. These incidents may result in acute or repetitive stress to the joint capsule and ligaments.

Shoulder ROM

The paradox of the thrower's shoulder is that to maximize performance, the athlete has to balance high flexibility, specifically in external ROM, with robust shoulder muscles for optimal shoulder stability (Wilk et al., 2002, 2009). If this balance is disturbed, tissue damage of the rotator cuff and repetitive subluxations of the shoulder may be the result.

In the present cohort, we detected a 3.3° (±5.9°) increase in ER and a 3.9° (±7.6°) decrease in IR between the dominant and nondominant arm. This finding is consistent with other studies of throwing athletes (Wilk et al., 2011); however we were unable to detect any differences in total ROM between dominant and nondominant shoulders. We were also unable to detect any differences in TRM between players with current or previous shoulder pain and those with no history of shoulder complaints. These findings suggest that a small increase in ER and a reduction of IR may be an adaptation caused by exposure to repetitive throwing, and that this adaptation is not directly associated with shoulder pain. However, as this is a cross-sectional study, these findings should be interpreted with caution.

It is also important to recognize that systematic measurement error may also explain our findings. For example, a different patient starting position on each side of the treatment table might also explain the small differences that we detected. However, standard goniometry has shown to have high intra-rater reliability for the measurement of shoulder IR and ER (Mullaney et al., 2010), and we made every effort to standardize our technique, with each examiner using the same hand position and test procedure for each player. Nevertheless, systematic error cannot be ruled out in our results.

Apprehension and relocation tests

Among all participating players, 29% experienced shoulder pain during the apprehension/relocation test, and the rate of positive tests was significantly higher among subjects with shoulder symptoms at the time of

testing than among pain-free subjects. This finding suggests that shoulder instability may be a common cause of shoulder pain in handball players. However, this must be interpreted with some caution given that we used pain as the major criterion for a positive test and not apprehension, which is the recognized criterion for diagnosis of instability (Speer et al., 1994).

Shooting velocities

The mean shooting velocity among the Norwegian elite female players was 75 km/h from the 7 m position and 82 km/h from the 9 m position. These velocities are almost identical to the results in the study by van den Tillaar and Ettema (2004) among male level-two handball players, who were measured to 78 km/h from the 7 m point.

It may be hypothesized that high shooting velocity is a risk factor for shoulder pain problems, as shoulder load increases with speed. We did not find any difference in shooting velocity among players with and without current pain or between players with and without previous pain. However, one explanation could be that current shoulder pain could lead to reduced shooting velocity. Also, it may be the fact that 12 out of the 65 players (18%) with current pain did not participate in the tests has affected the results.

WOSI

The WOSI questionnaire is a validated tool used for patients with shoulder instability. We chose to incorporate this questionnaire in the test battery to analyze to what degree the pain problems observed among elite female handball players can be compared with those reported by shoulder instability patients. In the present study, the handball players reported a similar total score (68% of normal) as that reported 32 months after a shoulder dislocation in patients treated nonoperatively (70%) (Kirkley et al., 2005). Even though a comparison of two different populations is challenging, the results indicate that many players perceive their shoulders as unstable.

Within the four domains of the WOSI questionnaire, the players scored lowest on "emotions." This is probably not surprising, as questions comprising this subscore relate to concerns about future exacerbations of shoulder symptoms. It was, however, more surprising that it was not the sub-score "sport" that achieved the lowest score, as many of the questions relate to activity level and performance. The players scored highest on the sub-score "lifestyle," which probably reflects the fact that the players do not change their way of living despite pain and negative emotions. They continue with high-level play and exposure but may adapt by changing their playing style, taking more the role of a playmaker with fewer shots, or change shooting technique to reduce the total shoulder load. Technique changes as a result of shoulder problems have also been observed among elite badminton players (Jost et al., 2005; Fahlström et al., 2006). Athletes with longstanding pain seem to develop coping strategies, which allow them to continue high-level play, at least to a certain degree.

Perspectives

Although we assume that longstanding pain will influence throwing and shooting technique, which again will most likely influence performance, we still need more data on how shoulder pain affects training and competition performance in handball. Data on intrinsic and extrinsic risk factors, as well as the injury mechanisms, are also needed. With this information, athletes at greater risk of developing injury may be identified early in their careers and targeted with individualized injury prevention strategies. This may reduce the risk of long-term health consequences and dropout from sports. However, basic information on shoulder injury epidemiology is lacking for most age-groups and playing levels. To this end, it is necessary to develop appropriate methodology to collect data on overuse injuries in prospective studies (Bahr, 2009). The final step in the injury prevention sequence is to introduce measures that are likely to reduce the future risk and/or severity of injuries and document whether they are effective. There are so far no such studies available in handball. We suggest that handball players focus on strengthening and stabilizing exercises for the rotator cuff and measures that secure scapula stability, ideally from an early age. Another aspect in prevention of shoulder pain among the overhead-throwing athletes may be to reduce the total shoulder load with respect to the number of throws per week and the number of matches played. However, this hypothesis needs to be examined in prospective studies.

Conclusions

A high proportion of elite female handball players suffer from a painful and/or unstable throwing shoulder. The pain substantially affects training and competition, although they continue to play with shoulder pain.

Key words: shoulder, injury, overuse, pain, WOSI, Fahlström.

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