PAIN OR NO PAIN – THE KINEMATIC CONSEQUENCES IN OVERHEAD THROWING WITHIN TEAM HANDBALL – A CASE STUDY

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Overuse injuries are unfortunately common in team handball. Non-optimal throwing kinematic is considered a risk factor in overhead sports, but no investigation has been presented if pain influence throwing kinematics or how it may affect the technique in an overhead throw in team handball players. The aim of the study was to investigate the impact of shoulder pain on throwing kinematics and neuromuscular activity within a female elite handball player – playing with shoulder pain and 4 years later, without shoulder pain. The main findings were that the maximal shoulder extension (8.9°), abduction (5.2°) and internal rotation (27.7°) increased in the no pain condition, while the highest muscular peak was found in the pain period for upper, middle and lower trapezius and in serratus anterior in the no pain condition.

KEYWORDS: Team handball, shoulder injuries, throwing kinematic.

INTRODUCTION: In handball many players play with shoulder pain during training and competition (Myklebust et al., 2013). Furthermore, 44-75 % of all the athletes had a history of shoulder pain, 30 % were playing with modifications, and had an influence of carrier choice after ending elite handball (Clarsen et al., 2014). Studies indicate that the total amount of training handball may be the cause of many overload shoulder injuries and players often continue playing handball despite pain. When an athlete experiences pain, one will adapt their movements and muscle activity pattern to avoid further pain (Laudner et al., 2006). Torabi et al. (2022) showed that some throwing kinematics varied between elite handball players playing with and without shoulder pain. However, it is not known if these variations are an adaptation to shoulder pain or a cause since not the same participants were compared before and after having shoulder pain. Therefore, this case study investigates the standing overhead throwing kinematics and neuromuscular activity within an elite female handball player that played with shoulder pain and four years later played without.

METHODS: The female elite handball player volunteered to the project after written and oral consent and Ethical approval was obtained for the project. The player was competing at the same level in both periods. The player threw five times with maximal speed with 30 second between each throw. The test position was seven metres from a net aiming at a square target area of 1x1 meter. A speedometer (Speedtrac X) was placed at the end of the room, behind the net, to collect data on throwing speed. A total of twenty-three markers were placed over anatomical landmarks on the pelvis, thorax, scapula, upper and lower arm in accordance with the recommendations by the International Society of Biomechanics (Wu et al., 2005) measured with 8 infrared cameras (Nexus 2.9, Vicon Motions Systems Ltd., Oxford, UK). In both sessions the same test protocol was followed and the placement of the markers were done by the same tester. Joint angles of the wrist, elbow, shoulder, trunk and pelvis were calculated using custom-made scripts in Matlab©. Maximal joint angles, angles at ball release and timing of maximal angles were calculated. Muscle activity was measured by bipolar surface EMG electrodes (Medicotest A-10-N, Ag/AgCl electrodes) on infraspinatus, serratus anterior, upper, middle and lower trapezius at ball release and 50 ms. before ball release. Raw EMG was collected with a frequency of 1000 Hz, pre-amplified and bandpass filtered (20-450 Hz). The EMG was filtered and smoothed with a fourth-order Butterworth filter of 10 Hz. Three maximal isometric maximal voluntary contractions (MVIC) of each muscle were performed to normalize the signal (Barbero, 2012). Pain was reported by the OSTRC Overuse injury of questionnaire, and its occurrence was reported by a custom-made questionnaire combined with an interview with a physical therapist. Means, SD and differences were calculated to present all data and

an independent t-test was performed on the kinematic and EMG data between the pain and no pain condition.

RESULTS: The physical activity and anthropometry was comparable at the two tests (table 1). At the first test the pain had been present for 6 months and had develop over time. It did not change the amount of participation in training volume, but reduced match participation by number of maximal throws. Subjectively level of experienced pain was described to 3 at the Visual Analogue Scale (VAS) and was localized in areas in the anterior, middle and posterior part of the shoulder.

Table 1. Physical activity scheme at time of testing

	With pain	No pain	Difference
Age (years)	22	26	4
Height (m)	1.85	1.85	0
Mass (kg)	82	76.8	5.2
BMI (kg/m^2)	24	22.2	1.8
Years practicing handball	17	21	4
Years as a professional athlete	2	6	4
Practice per week of handball (Hrs.)	5	5.5	0.5
Practice per week of strength training (Hrs.)	4	2	2

Maximal joint angles, angles at ball release and timing of maximal angles were different between the two test sessions. The maximal shoulder extension, abduction and internal rotation increased. Contrary, the maximal shoulder external rotation and trunk rotation decreased. When throwing with pain a larger shoulder flexion at ball release was found. Furthermore, timing of the maximal shoulder extension is positioned closer to ball release with no shoulder pain present.

Table 2: Mean ± SD joint angles and timing in Pain and in No Pain

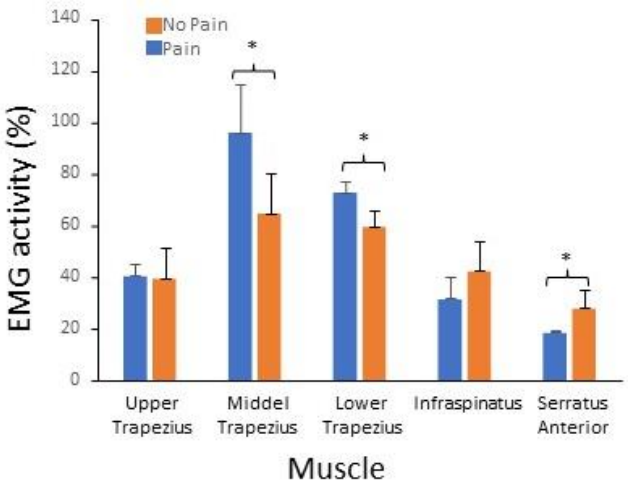
Variable	With pain	No pain	Difference
Maximal (°)			
Shoulder extension	11.1±1.7	20±2.2	8.9*
Shoulder abduction	93.6±1.6	98.8±3.1	5.2*
External rotation	170±2.8	159.2±3.3	10.8*
Internal rotation	17.6±2.4	45.3±8.4	27.7*
Pelvis rotation	-81.9±4.2	-73.7±3.3	8.2
Trunk rotation	-107.9±2.5	-85.7±1.1	22.2*
At ball release			
Shoulder flexion	-25.6±1.7	-15.1±2.2	10.5*
External rotation	138.3±3.9	140.5±8.5	2.2
Timing maximal angle (s)			
Shoulder extension	-0.404±0.021	-0.260±0.034	144*
External rotation	-0.032±0.003	-0.023±0.006	9*

* indicates a significant change from pre-to post test on a $p<0.05$ level.

The neuromuscular peak coordination was affected 50 ms before ball release, which is between maximal shoulder extension and maximal shoulder external rotation in the cocking

phase. Significantly differences were found in upper trapezius and lower trapezius, where the highest peak was in the pain condition. At ball release, the middle trapezius and lower trapezius had the highest peak in the pain condition, while serratus anterior had the highest peak in the no pain condition (Figure 1).

Figure 1: Peak EMG at ball release.



* indicates a significant change from pre-to post test on a $p<0.05$ level.

DISCUSSION: One female elite handball player participated in two cross-sectional studies investigating the potential impact of shoulder pain in throwing performance within team handball players (Torabi et al., 2022). The two data collections were done with 4 years apart. In the pain condition the maximal shoulder extension(MSE) occurred earlier before ball release with a higher maximal angle with a difference at almost 9° (table 2). This may be a consequent of pain management adaptations, where a decreased maximal angle can reduce the load on the anterior part of the shoulder (Borsa et al., 2008). After MSE, the shoulder has to transition during the cocking phase with maximal external shoulder rotation (MER). MER was increased in the pain condition and occurred earlier (table 2), which may increase the risk of internal impingement (Mihata et al., 2015). Furthermore, time spend in MER can create anterior/inferior pain. To compensate for time spend in maximal angles a longer ball acceleration phase may allow to lower force-induced stress on the different joints. In other words, this may be a way of reducing the pain-causing stresses in the anterior and inferior parts of the shoulder joint capsule (Miyashita et al., 2008). Furthermore, while the player had pain, a larger shoulder flexion was observed. The different position of shoulder flexion at ball release may be another adaption to create less stress on the glenohumeral joint, and this position of the humerus may influence in a shorter deceleration phase and follow-through (Meister, 2000). This may explain why an increased muscular peak is found in the trapezius muscles during the pain period, where a larger eccentric muscle contraction is necessary to compensate for a lower infraspinatus peak in the deceleration. The maximal internal rotation increased at the no pain test (table 2), which may indicate that the player generates more throwing velocity by shoulder rotation compared to the pain condition (Torabi et al., 2022).
Limitations are presents due to the methodological choice of this case study. The study shows differences in throwing kinematics and neuromuscular in one female elite handball player, but other players with pain could adapt differently or with higher level of pain affect differently? Or do the observed differences just represent an adaption to a previous injury conditions? Furthermore, no data has been collected if throwing velocity was influenced by pain or how the player adapted participating in match and training despite pain, so the role of performance is unknown. Future studies should investigate throwing movement patterns during periods where players are still participating in training and matches while experience shoulder pain.

Knowledge of individual adaptations before, during and after periods of injury can be used to develop strategies in increased training load and return to sport.

CONCLUSION: This case study measured one female elite handball player in two separate data collections with four years between the tests. Differences in throwing kinematics were found when comparing a standing overhead throwing. Maximal joint angles in shoulder extension, abduction, internal and external rotation increased, when the team handball player was throwing with no pain. Furthermore, the timing of the maximal shoulder external rotation and extension occurred earlier while throwing with shoulder pain.

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