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# A comparative study on shoulder pain, function, range of motion, and structure between handball players and non-throwing subjects

Comparative shoulder study in handball-players and non-throwing subjects

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## ABSTRACT

**Background:** Shoulder injuries are common in throwing athletes, however differences in shoulder pain, function, mobility, and structure compared with non-throwing subjects remain unclear. This study aimed to compare different variables related to pain, function, shoulder mobility, and anterior capsule-ligament complex thickness between handball players and a control group.

**Methods:** Fourteen handball players and seventeen control subjects were recruited (mean age 23.6±1.9 years). VAS at 4 different moments, DASH Score, shoulder external and internal active ROM, anterior glenohumeral gliding, posterior glenohumeral gliding, anterior capsule-ligament complex thickness, and pressure pain thresholds (supraspinatus, infraspinatus, teres minor, teres major, latissimus dorsi, pectoralis major) were measured.

**Results:** Handball players demonstrated higher values in VAS "pain right now" ($p=0.037$), VAS "average pain" ($p<0.001$), and VAS "at its worst" ($p=0.012$). Additionally, handball players evidenced higher DASH scores than the control group ($p=0.016$) and significantly lower internal rotation ROM ($p=0.004$).

**Conclusions:** This study suggests that handball players present more pain intensity, worse shoulder function with higher scores at the DASH questionnaire, and a reduction in active internal rotation ROM in the throwing-arm compared to non-throwing people.

## KEY WORDS

Handball, shoulder, ultrasonography, range of motion, trigger points.

# INTRODUCTION

Shoulder injuries are an important point of clinical interest in sports medicine, especially in throwing sports such as handball.(Achenbach et al., 2020; Doyscher, Kraus, Finke, & Scheibel, 2014) The shoulder needs to have a large range of motion to reach extreme positions of rotation, but at the same time, it needs to remain stable. This delicate balance between shoulder mobility and stability makes the shoulder joint prone to dislocation and injury.[1,3] In elite handball, shoulder injuries are highly prevalent: 44-75% of handball players have shoulder pain history and shoulder injuries represent 18% of the total frequency of injury locations.(Andersson, Bahr, Clarsen, & Myklebust, 2017; Doyscher et al., 2014)

Handball is a throwing sport characterized by a multitude of repetitive and highly specific patterns of throwing movements, where the shoulder is exposed to high demands due to repeated overhead motion at high velocity.[4] When such patterns are performed over a long period of time certain biological structures undergo adaptations that enable athletes to adequately process the load.[2] However, these adaptations may lead to non-physiologic loading of the periarticular soft-tissue, exceeding the stress tolerance of the structures and facilitating the overuse injuries.[2,3] Although a single traumatic event may injure handballer's shoulders, overuse injuries are more frequent.[3]

Therefore, good coordination and dynamic balance among the active and passive mechanisms, including periarticular muscles and static elements such as the joint capsule or the labrum,[5,6] are needed to keep joint stability.

It is essential to identify risk factors before pathological adaptations may result in pain and dysfunction. Besides the manual assessment, ultrasonography is a dynamic, real-time imaging modality that can improve cost efficiency and patient care.[7] It is based on sound waves emitted from a transducer, which are then bounced back off the underlying structures based on the density of that structure.[8] Hence, both manual and imaging assessment may help to identify these risk factors and prevent future injuries.

Previous ultrasonography studies have measured posterior capsule thickness in overhead athletes, finding that posterior capsule was thicker and stiffer in the throwing-shoulder when compared with the non-throwing shoulder.[9,10] Considering that, these adaptative changes may also occur in the anterior capsule.

The aim of this study was to compare different variables related to pain, function, shoulder mobility, and anterior capsule-ligament complex thickness between handball players and a non-throwing population control group. We considered the hypothesis that throwing mechanism in handball could produce structural and functional changes in the shoulder.

# MATERIALS AND METHODS

***Study design and participants***

This was a comparative, observational, cross-sectional study. The sample was composed of two different groups: handball players and non-throwing subjects (control group).

Thirty-one participants (mean age 23.6±1.9 years; 52% female) were recruited from private practice physiotherapy clinics or referred by handball teams. Fourteen subjects belonged to the handball players group and seventeen were control subjects.

The inclusion criteria were to be aged 18 or over and for the handball players group to have been training handball for at least 3 years before the study. The exclusion criteria were: previous history of shoulder surgery, luxation or subluxation in the throwing-arm, and people with overhead jobs (e.g. production line).[11]

Participation was voluntary and participants were informed of any potential risks and provided written consent prior to testing. The ethical approval for the study was obtained from the Clinical Research Ethics Committee of XXXXX (XXX/XXX) and all the procedures were conducted in accordance with the principles of the World Medical Association's Declaration of Helsinki.

***Procedures***

Data for each subject were collected during 1 testing session that lasted approximately 30 minutes. The physical evaluation was performed by 2 physical therapists with more than 5 years of experience. Demographic data were collected including age, gender, height, weight, and dominant side. Furthermore, the following clinical variables were measured: pain, pressure pain thresholds (PPTs), shoulder disability, shoulder mobility, glenohumeral gliding, and capsular anterior thickness.

***Pain***

A Visual Analogue Scale (VAS) was used to measure pain in four different moments during the last month: actual pain, typical or average pain, pain at its best, and pain at its worst. The Visual Analog Scale consisted of a 100 mm vertical line anchored by 2 verbal descriptors, one for each symptom extreme. This scale is most commonly anchored by "no pain" (score of 0) and "worst imaginable pain" (score of 100).[12]

***Pressure Pain Threshold (PPT)***

The PPT is defined as the least stimulus intensity at which a subject perceives mechanical pain to pressure.[13,14] Pressure pain threshold (PPT) was measured using a handheld pressure algometer (Wagner FPN100) in the myofascial trigger points (MTPs) of the following muscles: supraspinatus, infraspinatus, teres minor, teres major, latissimus dorsi, subscapularis, and pectoralis major. The probe (1 $cm^2$) was placed perpendicular to the skin. The pressure was applied at a rate of 30 KPa/s and participants were instructed to indicate when the sensation changed from a sensation of pressure to the first sensation of pain. Measurements were done with the subject resting in supine or prone position and the shoulder relaxed at 90º of abduction. PPTs were measured twice at each site, and the average was calculated. All sites were first located and marked. The PPT has been shown as a valid and reliable method to measure mechanosensitivity.[15,16]

***Shoulder Function***

The Spanish version of The Disabilities of the Arm, Shoulder, and Hand (DASHe) questionnaire was used to evaluate shoulder function.[17] The DASH score was developed as an outcome instrument for use in patients with complaints of the upper extremity and has shown good construct validity, test-retest reliability, and responsiveness to change.[18] It is a self-administered questionnaire that consists of 30 main questions and an optional additional 8 questions about work and sports and/or performing arts activities.[19]

***Active range of motion (ROM) of external rotation (ER) and internal rotation (IR)***

A smartphone (Samsung Galaxy S7) with the Clinometer Application version 2.4 was used to assess the asymptomatic active movement of external and internal rotation of the shoulder[20]. The Clinometer App is a valid instrument for measuring shoulder ROM in both healthy and symptomatic subjects.[20]

Rotations were measured with the subject lying in supine position, with the glenohumeral joint in 90º of abduction. The scapula was stabilized by an examiner's hand and the arm rotated until scapular motion was detected, in order to isolate glenohumeral joint movement.[9,10] The smartphone was placed on the forearm's ventral aspect for ER and the dorsal aspect for IR.[20]

***Anterior and posterior glenohumeral gliding***

Glenohumeral anterior and posterior translation was measured using the TELEMED LS64 ultrasound scanner. This technique has shown good levels of intra-rater reliability (ICC=0.85-0.98)[21] of both anterior and posterior glenohumeral translations in physiotherapists with minimal training.

The anterior and posterior translation of the humeral head were assessed in the seated position with patient´s forearm laying on a table and a wedge placed in their axilla to get a standardized position of 24° of abduction[22]. Lin et al.[22] demonstrated that the maximum anteroposterior and posteroanterior translational mobility in a seated position occurs at approximately 24° of glenohumeral abduction.

An examiner placed the linear-array transducer on the ventral aspect of the shoulder. The location of the transducer was then adjusted to optimize the visualization of the coracoid process at its highest point and the anterior surface of the humeral head. Another examiner was behind the subject with one hand stabilizing the scapula and the other hand gliding the humeral head to anterior and posterior. The ultrasound reference position was defined as the distance in millimeters between the coracoid process and the most ventral part of the humeral head in a resting position (blue line in Figure 1).

***Anterior capsule thickness***

The anterior capsule-ligament complex, in resting position, was measured in millimeters using the TELEMED LS64 ultrasound scanner (green line in figure 1). Subjects remained in the same position as the previous assessment.

***Statistical Analysis***

Data were analyzed using the statistical software package SPSS for Windows v20.0 (SPSS Inc., Chicago, IL, USA). Mean and standard deviations were calculated for quantitative variables. Frequencies and percentages were calculated for qualitative variables. The Shapiro-Wilk test was used to assess the normal distribution of quantitative data. Between-groups comparisons of quantitative variables were analyzed by Student's T-test or the Mann-Whitney U test, for normally distributed data or non-normally distributed data respectively. Between-groups comparisons of qualitative variables were analyzed by Chi-Square Test. The level of significance was established at $p<0.05$.

# RESULTS

Thirty-one patients were screened, 14 (45%) belonged to the handball players group and 17 (55%) belonged to the control group. The demographic data of the sample are shown in Table I.

Significant differences in pain and function were observed between groups. Handball players demonstrated higher values in VAS “pain right now” ($p=0.037$), VAS “average pain” ($p<0.001$), and VAS “at its worst” ($p=0.012$). Handball players showed at least 1 point more in “average pain” and “pain at its worst” than the control group. No significant difference was found for VAS “at its best” ($p=0.216$).

Handball players evidenced higher scores for DASH score (4.70, SD=5.13) compared to control group (0.98, SD=1.45) ($p=0.016$). Handball players exceeded 4 points the control group, which means they had worse shoulder function.

Regarding ROM, handball players demonstrated a significantly lower internal rotation (52.09°, SD=8.95) than the control group (60.39°; SD=5.95) ($p=0.004$). They showed, on average, almost 10 degrees less of IR ROM. However, no significant differences were observed in external rotation ($p=0.750$).

No significant differences between groups were found for the ultrasonographic variables ($p=0.330$-$0.702$) or PPTs ($p=0.065$-$0.950$). The data of each variable are shown in Table II.

## DISCUSSION

The main purpose of this study was to compare pain, function, mobility, and structure of the shoulder between handball players and a control group of non-throwing subjects. This study has proved that handball players presented more pain intensity, less level of function, and a reduced active internal rotation ROM compared to a control group. However, no significant differences were found in antero-posterior glidings, anterior capsule-ligament thickness, or PPT values.

Handball players showed higher values for VAS at three different moments: pain right now, average pain, and pain at its worst. No literature has been found comparing both populations, although different studies have shown that as many as 75% of handball players present shoulder pain.[4,23,24] These studies have shown that prevalence of current shoulder pain is between 20-52%, which corresponds to our "pain right now" VAS outcome.

Handball players showed worse shoulder function (higher scores in DASH questionnaire) than the control group, as previously demonstrated.[25,26] De Oliveira et al.[25] also showed that in presence of shoulder pain, the upper limb reduces its function levels, with a negative impact on daily activity and sports skills.

In the current study, no significant differences were found in active external rotation ROM between groups. These results are in line with previous evidence in a female population.[27] However, Nodehi-Moghadam et al.[28] found that external rotation was higher in the throwing-group than in the non-throwing group. These differences may be because Nodehi-Moghadam et al.[28] measured passive ROM instead of active ROM.

Otherwise, handball players presented a significative reduced active internal rotation ROM compared to the control group.

A similar finding, commonly referred to as GIRD (Glenohumeral Internal Rotation Deficit), which is measured comparing the throwing-arm with the non-throwing arm, has been widely documented.[29–31]. According to this, our findings could indicate that the difference in the ROM depends on whether the arm is a throwing arm or not.

This contrasts with other authors who didn't find a deficit in internal rotation in throwing groups due to differences in the methodology or sample. Nodehi-Moghadam et al.[28] assessed passive ROM and Quadros et al.[27] evaluated only females between 15 and 17 years old, while our study assessed active ROM and the sample included men and women older than 18.

Previous studies proved by ultrasonography that the posterior capsule of throwing-shoulders was thicker and stiffer than in non-throwing shoulders in a side-to-side comparison [9,10]. The present study assessed the anterior capsule-ligament complex, but there were no significant differences in the thickness of the structure. To our knowledge, this is the first study to investigate anterior capsule-ligament thickness using ultrasound imaging in throwing and non-throwing subjects. It could be because the structural changes already described in the posterior capsule are not enough in order to produce structural changes in the anterior capsule.

No significant differences were found between groups in anterior and posterior glenohumeral gliding. Comparisons of these results are limited because, to our knowledge, this is the first study that compares anterior and posterior glenohumeral gliding assessed by ultrasound imaging between handball players and a control group. Only one study has been found comparing translations in rugby players with a healthy shoulder and with an unstable shoulder. Cheng et al.[32] found that those with an unstable shoulder had a significantly higher mean shoulder translation in all directions compared to the players with a healthy one. Comparisons with this study are limited because of differences in the position for the assessment of the translation. Cheng et al.[32] evaluated with the arm internally rotated and fixed to the body, with the elbow flexed to 90º and supported by a sling; while in the current study, subjects were evaluated in the position where maximum anteroposterior translation has been demonstrated (i.e. elbow flexed 90º, shoulder in neutral rotation, and 24º abducted).[22] The different outcomes may also be because this study compared healthy handball players with healthy non-throwing people, not healthy shoulders with unstable shoulders.

Regarding the pressure pain threshold, no significant differences were found in PPT values between both groups. There is limited evidence about PPT values of the muscles studied and no previous studies have been found comparing PPT between handball players and a control group. However, Habechian et al.[33] compared PPT of the scapular region between amateur swimmers, competition swimmers, and non-practitioners. No differences were demonstrated for any of the muscles among the 3 groups, in line with our results. These findings could be due to the high prevalence of latent trigger points in the shoulder girdle muscles in the broader population (nearly 90%).[34]

To the best of the authors knowledge, no study has previously evaluated the adaptation of the anterior capsule of the shoulder between 2 different groups (handball players and non-throwing subjects). As a limitation, this study was conducted with relatively small sample size, so investigators should be careful in the interpretation of the results. Future research could investigate the differences according to sex, considering that other authors found differences in soft-tissue adaptations between male and female players.[35]

## CONCLUSIONS

The present study suggests that handball players present more pain intensity, worse shoulder function with higher scores at the DASH questionnaire, and a reduction in active internal rotation ROM in the throwing-arm compared to non-throwing people.

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## CONFLICTS OF INTEREST

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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## AUTHORS' CONTRIBUTIONS

All the authors have been actively involved in the planning and enactment of the review and have also assisted with the preparation of the submitted article. All the authors meet the criteria for authorship and have read and approved the manuscript, are responsible for the reported research and have contributed significantly to the research of the present manuscript.

**Table I.** Descriptive data of the total sample including demographic variables.

| | **Variables** | **Mean ± SD/Percentage** |
|---|---|---|
| **Demographic data** | Sex (%female/%male) | 52% /48% |
| | Dominant side (%right-handed/%left-handed) | 87% / 13% |
| | Age (years) | 23.70 ± 1.90 |
| | Height (m) | 1.73 ± 0.09 |
| | Weight (kg) | 71.26 ± 13.06 |
| | BMI (kg/m2) | 23.59 ± 2.76 |

**Table II.** Between groups comparison of demographic and clinical variables.

| | Variables | Handball group n=14 | Control group n=17 | *p* value (effect size) |
|---|---|---|---|---|
| **Demographic** | Sex (% female / male) | 35.7% / 64.3 % | 65.7% / 35.3% | 0.108[c] |
| | Dominant side (% right-handed / left-handed) | 78.6% / 21.4% | 94.1% / 5.9% | 0.199[c] |
| | Age (years) | 24.21 ± 1.72 | 23.18 ± 1.94 | 0.242[b] |
| | Height (m) | 1.76 ± 0.08 | 1.71 ± 0.09 | 0.099[b] |
| | Weight (kg) | 77.22 ± 13.33 | 66.35 ± 10.90 | **0.018[a]** (-0.902) |
| | BMI (kg/m$^2$) | 24.78 ± 2.82 | 22.60 ± 2.35 | **0.026[a]** (-0.848) |
| **Pain and function** | (VAS) Pain right now (cm) | 0.48 ± 0.60 | 0.13 ± 0.39 | **0.037[b]** (-0.707) |
| | (VAS) Average pain (cm) | 1.15 ± 1.21 | 0.13 ± 0.24 | **<0.001[b]** (-1.23) |
| | (VAS) Pain at its best (cm) | 0.10 ± 0.18 | 0.03 ± 0.08 | 0.216[b] |
| | (VAS) Pain at its worst (cm) | 2.82 ± 2.10 | 1.14 ± 1.73 | **0.012[b]** (-0.882) |
| | DASH Score (%) | 4.70 ± 5.13 | 0.98 ± 1.45 | **0.016[b]** (-1.033) |
| **ROM and capsule thickness** | External rotation active ROM (degrees) | 99.38 ± 7.88 | 98.31 ± 10.68 | 0.750[a] |
| | Internal rotation active ROM (degrees) | 52.09 ± 8.95 | 60.39 ± 5.95 | **0.004[a]** (1.115) |
| | Anterior glenohumeral glide (mm) | 4.73 ± 3.35 | 4.31 ± 2.75 | 0.702[a] |
| | Posterior glenohumeral glide (mm) | 9.87 ± 5.21 | 8.23 ± 4.07 | 0.333[a] |
| | Anterior capsule-ligament complex thickness (mm) | 5.98 ± 1.82 | 5.49 ± 1.45 | 0.330[b] |
| **Mechanosensitivity (PPT)** | PPT supraspinatus (Kg/cm2) | 4.00 ± 0.75 | 4.02 ± 0.80 | 0.940[a] |
| | PPT infraspinatus (Kg/cm2) | 3.62 ± 0.62 | 4.26 ± 1.09 | 0.065[b] |
| | PPT teres minor (Kg/cm2) | 3.47 ± 0.80 | 3.81 ± 1.05 | 0.330[a] |
| | PPT teres major (Kg/cm2) | 3.64 ± 0.92 | 3.57 ± 0.70 | 0.830[a] |
| | PPT latissimus dorsi (Kg/cm2) | 4.29 ± 0.24 | 4.06 ± 0.85 | 0.560[a] |
| | PPT subscapularis (Kg/cm2) | 4.43 ± 0.70 | 4.46 ± 1.53 | 0.950[a] |
| | PPT pectoralis major (Kg/cm2) | 2.89 ± 0.81 | 2.97± 0.73 | 0.780[a] |

**Note:** Level of significance, $p \leq 0.05$

a. Student's t-test  b. Mann-Whitney U test  c. Chi-Square Test

**Figure 1.** Short axis ultrasound view of the humeral head and coracoid process in resting position.