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# Dry Needling versus Diacutaneous Fibrolysis for the Treatment of the Mechanical Properties of the Teres Major Muscle: A Randomized Clinical Trial

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**Abstract:** (1) Background: The stiffness of the posterior shoulder muscles has been shown to be related to shoulder pain and range of motion (ROM) restriction in athletes. Specifically, the treatment of the teres major muscle showed promising results in previous studies. The aim of this study was to compare the effects of dry needling (DN) vs. diacutaneous fibrolysis (DF) to improve the stiffness and tone of the teres major muscle, pain intensity, shoulder ROM, and extensibility in the short-term and at one-week follow-up in handball athletes. (2) Methods: A randomized clinical trial with blinded examiners was carried out. Elite handball athletes with shoulder pain and glenohumeral internal rotation deficit ($n = 30$) were randomly allocated to the DN group or the DF group. Patients in both groups received a single treatment session directly applied to the teres major muscle. The primary outcome variables and instrument were mechanical properties of the teres major muscle (stiffness and tone) measured with myotonometry. The secondary outcome variables were intensity of shoulder pain evaluated with visual analogue scale and shoulder ROM and extensibility recorded with a digital inclinometer. (3) Results: No between-group differences were found after the intervention or at one-week follow-up in the mechanical properties of teres major muscle, pain intensity, shoulder ROM, or extensibility. (4) Conclusions: the DN and DF techniques showed similar results at both timepoints in elite handball athletes with shoulder pain and glenohumeral internal rotation deficits.

**Keywords:** shoulder pain; trigger points; dry needling; range of motion



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## 1. Introduction

Handball is a sport with a high risk of injury due to its intensity and physical contact. Men have the highest injury rates per 1000 h of exposure and the shoulder complex is one of the most susceptible regions to injuries [1]. The shoulder complex of handball athletes presents several adaptations due to the repeated throwing actions at high velocity, such as glenohumeral internal rotation deficit (GIRD) of the throwing shoulder (TS), reduction in the total rotation range of motion (tROM), and limitation of the horizontal adduction (HA) ROM [2–5]. These adaptations are considered risk factors for pain and injuries when the GIRD is higher than 15° [6] and the tROM reduction is higher than 10° [3]. In these cases, the handball athletes present twice the risk of suffering pain and/or injuries in several shoulder structures [3].

Posterior muscle stiffness seems to be the source of these shoulder adaptations [4–9]. Specifically, the teres major muscle seems to have a special relationship with the shoulder function. Barra-López et al. suggested that this muscle promotes glenohumeral stability by resisting inferior displacement of the humeral head with the arm lifted [10]. The mechanical properties, like stiffness and tone, of this muscle have shown to be increased in TS compared to non-TS and non-handball athletes [11]. Therefore, the increase in the stiffness of the teres major muscle may reach the humeral head, favoring GIRD and reductions in tROM and HA. Despite the fact that no study has investigated the correlation between the properties of the teres major muscle and glenohumeral ROM, its treatment immediately improved pain intensity, shoulder ROM restrictions, and extensibility in handball athletes [7].

The management of the teres major muscle in patients with shoulder pain and ROM restrictions seems to be a promising approach. Dry needling (DN) and diacutaneous fibrolysis (DF) are the two most common instrumental techniques used for different shoulder and upper-body dysfunctions [7,12–19]. DN is an instrumental invasive technique while DF is a conservative instrumental technique. DN uses stainless single-use acupuncture needles to eliminate or inactivate myofascial trigger points in the soft tissues by eliciting local twitch responses [20]. DF is an instrument-assisted soft tissue technique based on the Cyriax principles that uses a metallic hook to achieve a deeper and more precise application. Both techniques have shown to be effective in decreasing muscle stiffness immediately after the intervention and at 30 m [21] to 72 h of follow-up [22]. Moreover, these techniques have proven to be clinically effective in a wide range of musculoskeletal conditions. But not all patients can tolerate invasive techniques. So, considering that no study has compared the effects of both techniques on the stiffness of the teres major muscle in elite handball athletes, we wanted to investigate if both techniques presented similar changes.

Thus, the primary objective of this randomized controlled trial was to compare the effects of the DN technique and the DF technique on the stiffness of the teres major muscle; the secondary objective was to compare the effects of both interventions in teres major muscle tone, pain intensity, shoulder ROM, and posterior shoulder extensibility in handball athletes with shoulder pain and GIRD.

## 2. Materials and Methods

### 2.1. Study Design

A randomized controlled trial with blinded examiners was carried out between September and December 2021. Ethical approval was granted by the Research Ethics Committee of Valladolid Este (CASVE-NM-21-538) and the study followed the Consolidated Standards of Reporting Trials (CONSORT) guidelines. The protocol of this study was prospectively registered in clinicaltrials.gov (accessed on 2 September 2021) and given a unique identification number (NCT05080439).

### 2.2. Sample Size

Muscle stiffness was considered the primary outcome and was used to calculate the sample size using the Minitab 13.0 program. Assuming a between-group mean value of 24.91 (N/m) for myotonometry, considering the minimum detectable change (MDC) and a standard deviation (SD) of 24 (N/m) according to a previous pilot study, and estimating a two-tail test level of significance of 0.05 and a follow-up loss rate of 15%, 15 handball athletes were necessary for each group.

### 2.3. Participants

Thirty male elite handball athletes (mean age 25.83 ± 5.39) recruited from professional handball teams in Spain met the eligibility criteria and were randomly allocated to the DN group or to the DF group. Inclusion criteria were as follows: (1) elite male handball athletes with reproducible shoulder pain during throwing actions; (2) aged between 18 and 30 years of age; (3) a GIRD value >15° [6]; (4) a minimum of 2 years as an elite athlete, and a practice routine of a minimum of 2 h/day and 3 days/week; and (5) presence of an active myofascial trigger point (MTrP) in the teres major muscle. The identification of the MTrP in the teres major muscle was performed according to the latest Travel and

Simons criteria [23]. Exclusion criteria were as follows: (1) previous fracture, dislocation, or surgery in any joint of the upper limb, cervical spine, or thoracic spine; (2) use of any type of pharmacological treatment (such as analgesics, muscle relaxants, or others); (3) previous experience with DN or DF; (4) DN or DF contraindications (e.g., cutaneous lesions or vascular abnormalities); and (5) modifications to sport practice or daily living activities during the study process.

### *2.4. Allocation and Blinding*

The allocation was randomly performed by an external assistant using the Research Randomizer (version 4.0). The external assistant created a random number sequence before the first patient was recruited and was blinded to the rest of the study processes. The examiners that performed the measurements were blinded to the patient allocation.

### *2.5. Interventions*

All participants received one session of invasive DN or conservative DF treatment corresponding to the assigned group. The therapist that applied both interventions was an expert physiotherapist with more than 10 years of clinical experience using both instrumental techniques. The time spent in each treatment session was similar in both groups, without exceeding 20 m in either case. In both groups, the participants were instructed to lie in prone position with the shoulder at 90° abduction and the elbow at 90° flexion. A towel was placed in the anterior part of the shoulder to ensure the correct position and to prevent HA.

DN is an instrumental invasive technique that consists of localizing and holding the MTrP of the teres major between the therapists' thumb and index fingers. Once the MTrP was stabilized, a 0.25 × 50 mm needle was inserted multiple times into the teres major muscle to elicit local twitch responses following the basis of the fast-in fast-out technique [24,25]. The needle was inserted until no local twitch responses were elicited [26]. When the needle was removed, the treated area was compressed to achieve hemostasia (Figure 1).

**Figure 1.** DN of teres major muscle.

DF is a conservative instrumental technique consisting of the application of a hook following the intermuscular septum muscles around the teres major (teres minor, triceps brachialis, and latissimus dorsi muscle). The procedure was performed as follows: First, the muscle structure was determined to mobilize with the left hand. Secondly, the tissues were moved manually with the right hand and the hook was adapted to the muscular volume. Finally, both the hands and the hook performed a traction movement on the soft tissues to move them in a transversal direction (Figure 2).

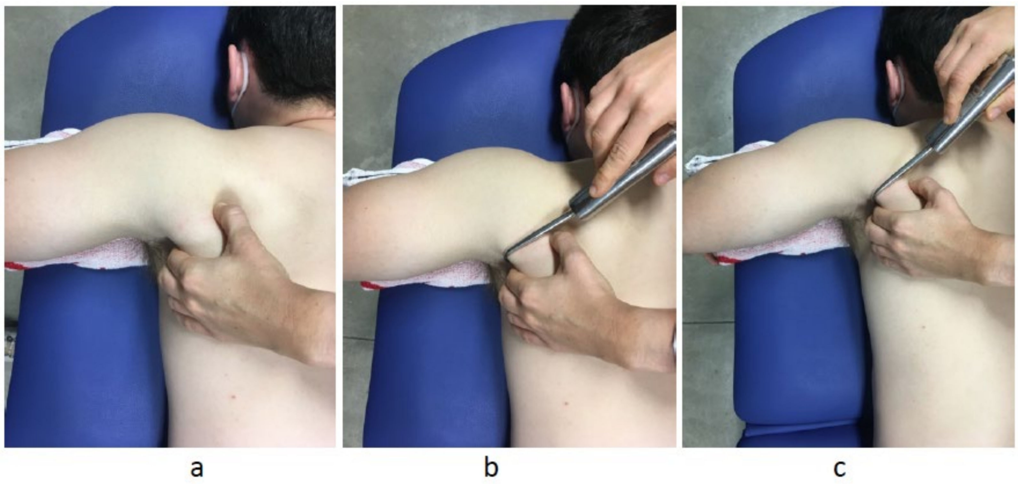


**Figure 2.** DF application: (**a**) manual palpation; (**b**) instrumental adaptation; (**c**) transversal movement of soft tissues.

### *2.6. Outcomes and Measurement Instruments*

The primary outcome measure was stiffness of the teres major muscle measured via myotonometry. Secondary outcome measures were tone of the teres major muscle, pain intensity, internal and external ROM, and posterior shoulder extensibility. All the measurements were recorded by the same two blinded examiners at baseline, after the intervention and at one week follow-up.

#### 2.6.1. Mechanical Properties of the Teres Major Muscle

Mechanical properties were measured using MyotonPRO (Mumeetria Ltd., Tallinn, Estonia). The device measures mechanical oscillations using a short-duration mechanical impulse (15 ms) and constant mechanical force (up to 0.6 N). The variables obtained from this procedure are stiffness (N/m) and frequency or tone (Hz) [27]. Three measurements were performed in the teres major muscle with 10 min of rest between trials, and the average of all the trials was used for statistical purposes.

The patient was asked to lie in prone position with the shoulder at 90° abduction, neutral internal and external shoulder rotation, the elbow at 90° flexion, and the wrist in neutral position. Prior to myotonometry, a 10 m rest was allowed to avoid invalid data. The muscle belly and the direction of the muscle fibers of the teres major muscle were identified via manual palpation according to previous protocol studies [28,29]. After the 10 m rest, the testing end of the device was placed on the skin perpendicular to the surface of the muscle belly over the site located. The device was moved into the measurement position and automatically performed the predefined series of measurement.

#### 2.6.2. Pain Intensity

Pain intensity was recorded with a 10 cm Visual Analogic Scale (VAS). VAS is a 10 cm horizontal line in which one limit represents "no symptoms" and the opposite limit represents "the most intense pain imaginable". VAS has shown to be a valid and reliable tool for patients with shoulder pain reporting excellent intra-rater and inter-day reliability values [30].

#### 2.6.3. ROM

All the shoulder ROM assessments were registered using a digital inclinometer. Passive shoulder internal and external rotation ROMs were recorded in the TS and non-TS following the protocol described by Fiesseler et al. [8,9]. Shoulder rotation ROMs were measured in both arms in order to calculate GIRD. GIRD had to be higher than 15° in all the handball athletes because it was considered an inclusion criterion, and was calculated by resting the internal rotation ROM of the TS to the internal rotation ROM of the non-TS. tROM was calculated by summing the internal and external rotation ROM of the TS shoulder [8,9]. Passive HA ROM was recorded only in the TS following the protocol described by Laudner et al. [31].

For measuring passive internal and external rotation ROM, the patient was instructed to lie supine with the shoulder at 90° abduction and the elbow at 90° flexion. A towel was placed in the posterior part of the shoulder to ensure the correct position and to prevent horizontal abduction. One examiner stabilized the scapula with one hand and performed the internal or external rotation movement with the other hand. The second examiner recorded the ROM when the first examiner felt the scapula move.

For measuring passive HA ROM, the patient was instructed to lie supine with the shoulder at 90° abduction. One examiner applied pressure on the lateral edge of the scapula with one hand in order to stabilize it and used the other hand to perform the passive HA movement. The second examiner recorded the ROM when the first examiner felt the scapula move by placing the digital inclinometer on the midline of the posterior humeral face. A degree of 0° was considered the point when the humerus was perpendicular to the examination table [32].

#### 2.6.4. Posterior Shoulder Muscle Extensibility

Extensibility was measured using a digital inclinometer as well and following the test proposed by Tyler et al. [33,34]. The patient was instructed to lie on the contralateral side with the shoulder at 90° abduction. The examiner used one hand to stabilize the scapula and let the humerus drop. The second examiner recorded the ROM when the first examiner felt the scapula move by placing the digital inclinometer on the midline of the posterior humeral face. A degree of 0° was considered the point when the humerus was perpendicular to the examination table.

### *2.7. Reliability of the Measures*

To investigate if the changes identified in this study were clinically relevant, the intraclass correlation coefficient (ICC), standard error of measurement (SEM), and MDC were calculated through a test–retest reliability assessment. The reliability study was considered for the primary and secondary outcomes of this study but pain intensity. All the outcome measurements were performed by the same examiners and followed the same procedures described above. The results obtained come from 10 athletes who were evaluated on the same day of the study with 15 min of rest between evaluations (Table 1).

**Table 1.** Test–retest reliability of the outcome variables.

| | ICC (95% CI) | SEM | MDC |
|---|---|---|---|
| ER ROM (°) | 0.92 (0.88, 0.95) | 2.29 | 6.35 |
| IR ROM (°) | 0.93(0.89, 0.97) | 1.83 | 5.07 |
| HA ROM (°) | 0.90 (0.83, 0.97) | 2.27 | 6.29 |
| Extensibility (°) | 0.92 (0.9, 0.94) | 2.23 | 6.19 |
| Tone (Hz) | 0.98 (0.96, 0.99) | 0.29 | 0.80 |
| Stiffness (N/m) | 0.97 (0.95, 0.98) | 8.99 | 24.91 |

ICC: intraclass correlation coefficient; CI: confidence interval; SEM: standard error of measurement; MDC: minimal detectable change; ER: external rotation; IR: internal rotation; HA: horizontal adduction; ROM: range of motion.

### *2.8. Statistical Analysis*

Statistical analysis was performed using SPSS version 20.0 for Windows. Before performing the comparative analysis, the normal or non-normal distribution of the quantitative variables was tested using the Shapiro–Wilk test. A linear mixed model with repeated-measures analysis was used to investigate the differences in outcomes in terms of time (baseline, postintervention, and one-week follow-up) and group (DN and DF). Analysis was performed on an intention-to-treat principle. Change scores from baseline were calculated for postintervention and one-week follow-up. A $p$-value < 0.05 was considered statistically significant. The magnitude of the differences was classified according to the value of Cohen's d. The effect size was considered small if the Cohen's d value ranged from 0.2 to 0.5, moderate from 0.5 to 0.8, or large if the value was greater than 0.8 [35].

## 3. Results

Thirty-eight elite handball athletes with shoulder pain and GIRD were screened for eligibility criteria. Eight elite handball athletes were excluded for different reasons. Five did not present shoulder pain and did not present a GIRD > 15° and one declined to participate. Finally, thirty athletes met the eligibility criteria, agreed to participate, and were randomized into the DN group or the DF group. No dropouts occurred during the study. The study flowchart is shown in Figure 3.

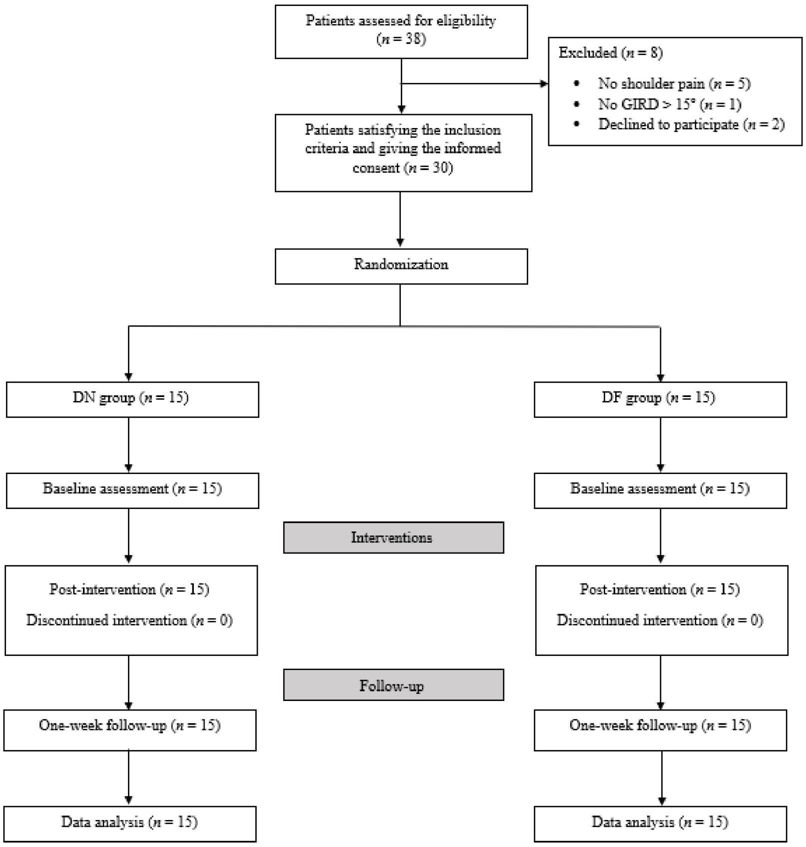


**Figure 3.** Flowchart of the study process.

Demographic variables were similar in both groups at baseline without statistically significant differences between them ($p$ > 0.05). The mean, standard deviations, and $p$-values of the registered demographic variables are shown in Table 2.

The baseline, change scores at both timepoints (after the intervention and at one-week follow-up), between-group change scores, and the effect size of the difference for the primary and secondary outcome variables are presented in Table 3. No statistically significant differences were found for the between-group changes score of either the primary outcome (stiffness) or the secondary outcomes (tone, pain intensity, shoulder ROM, or extensibility) ($p$ > 0.05).

**Table 2.** Demographic characteristics at baseline.

| Characteristics | DN Group (n = 15) | DF Group (n = 15) | *p*-Value |
|---|---|---|---|
| Age (years) | 25.47 ± 4.99 | 26.20 ± 5.91 | F = 0.13<br>0.717 |
| Height (cm) | 184.13 ± 4.61 | 183.20 ± 7.46 | F = 0.17<br>0.684 |
| Weight (kg) | 85.13 ± 8.58 | 89.53 ± 15.01 | F = 0.97<br>0.333 |
| BMI (Kg/cm$^2$) | 25.07 ± 1.98 | 26.50 ± 2.60 | F = 2.83<br>0.103 |
| Training days per week (h/w) | 4.13 ± 0.87 | 4.26 ± 0.77 | U = 105.50<br>0.775 |
| Months since first symptoms | 35.00 ± 24.25 | 47.33 ± 33.83 | F = 1.31<br>0.261 |

DN: dry needling; DF: diacutaneous fibrolysis; BMI: body mass index. Values are expressed as mean ± SD.

**Table 3.** Baseline, postintervention, and follow-up change scores for the outcome variables.

| Outcome | DN Group (*n* = 15) | DF Group (*n* = 15) | Between-Group Difference in Change Score | Effect Size of Difference |
|---|---|---|---|---|
| *Stiffness [N/m]* | | | | |
| Baseline | 173.47 ± 25.50 | 173.21 ±26.60 | | |
| Postintervention change score | −18.33 ± 14.08 | −21.28 ± 16.48 | −2.95 (−14.60, 8.70) | 0.1 |
| One-week follow-up change score | −7.6 ± 34.08 | −22.57 ± 11.52 | −14.97 (−34.65, 4.71) | 0.5 |
| *Tone [Hz]* | | | | |
| Baseline | 11.32 ±0.38 | 11.57 ±0.61 | | |
| Postintervention change score | −0.39 ± 0.37 | −0.19 ± 0.45 | 0.20 (−0.11, 0.51) | 0.4 |
| One-week follow-up change score | −0.16 ± 0.53 | −0.30 ± 0.56 | −0.13 (−0.55, 0.28) | 0.2 |
| *VAS [points]* | | | | |
| Baseline | 4.36 ± 2.18 | 3.90 ± 2.24 | | |
| Postintervention change score | −4.36 ± 2.18 | −3.90 ± 2.24 | 0.45 (−1.22, 2.14) | 0.2 |
| One-week follow-up change score | −2.54 ± 1.63 | −2.10 ± 2.51 | 0.53 (−1.06, 2.14) | 0.2 |
| *IR ROM [°]* | | | | |
| Baseline | 19.07 ± 6.59 | 15.79 ± 3.51 | | |
| Postintervention change score | 16.40 ± 9.25 | 15.21 ± 7.24 | −1.18 (−7.55, 5.18) | 0.1 |
| One-week follow-up change score | 13.73 ± 7.13 | 14.35 ± 6.46 | 0.63 (−4.57, 5.82) | 0.1 |
| *ER ROM [°]* | | | | |
| Baseline | 76.67 ± 10.30 | 75.29 ± 10.48 | | |
| Postintervention change score | 7.26 ± 17.69 | 7.92 ± 10.49 | 0.66 (−10.52, 11.85) | 0.1 |
| One-week follow-up change score | 6.40 ± 17.05 | 8.28 ± 12.97 | 1.88 (−9.72, 13.49) | 0.1 |
| *tROM [°]* | | | | |
| Baseline | 95.73 ± 11.06 | 91.07 ± 11.20 | | |
| Postintervention change score | 23.66 ± 23.25 | 23.14 ± 13.09 | −0.52 (−15.05, 14.00) | 0.1 |
| One-week follow-up change score | 20.13 ± 21.68 | 22.64 ± 15.56 | 2.50 (−11.96, 16.98) | 0.1 |
| *HA ROM [°]* | | | | |
| Baseline | −9.93 ± 5.32 | −9.57 ± 4.40 | | |
| Postintervention change score | 14.53 ± 11.12 | 13.57 ± 6.52 | −0.96 (−7.97, 6.05) | 0.1 |
| One-week follow-up change score | 19.73 ± 9.04 | 21.00 ± 10.16 | 1.26 (−6.05, 8.58) | 0.1 |
| *Extensibility [°]* | | | | |
| Baseline | −12.20 ± 8.36 | −10.93 ± 9.59 | | |
| Postintervention change score | 6.13 ± 6.85 | 7.37 ± 6.97 | 1.22 (−4.04, 6.49) | 0.1 |
| One-week follow-up change score | 5.80 ± 10.92 | 8.21 ± 8.34 | 2.41 (−5.03, 9.86) | 0.2 |

DN: dry needling; DF: diacutaneous fibrolysis; VAS: visual analog scale; ROM: range of motion; IR: internal rotation; ER: external rotation; tROM: total range of motion; HA: horizontal adduction. Values are expressed as mean ± SD.

The within-group analysis showed that no group achieved changes higher than the MDCs at any timepoint for muscle stiffness and muscle tone. Regarding the secondary variables, both groups achieved changes higher than the MDCs for shoulder ER, IR, and HA ROM. For extensibility, only the DF group showed results higher than the MDC.

## 4. Discussion

The present study aimed to compare the effects of the DN technique and the DF technique on the stiffness and tone of the teres major muscle, pain intensity, shoulder ROM, and posterior muscle shoulder extensibility. The results of our study showed that a single session of an invasive instrumental technique or a conservative instrumental technique in the teres major muscle decreased teres major muscle stiffness and improved pain intensity, shoulder ROM, and extensibility immediately after the intervention and at one-week of follow-up without statistically significant differences between both groups.

Concerning the mechanical properties, muscle stiffness is defined as the ratio of the change in resistance to the change in length [36], and muscle tone is characterized by the muscle stiffness together with elastic properties and neurogenic factors and is responsible for ensuring efficient muscle contraction, such as in steady-state conditions without voluntary contraction [37]. Previous studies have investigated the effects of DN and DF on the mechanical properties of different muscles. Sánchez-Infante et al. [22] found a decrease in upper trapezius muscle stiffness at 72 h of follow-up with a moderate effect size after a single session of DN, but no changes were found in tone. López-de-Celis et al. [21] found a decrease in gastrocnemius muscle stiffness and tone at 30 m of follow-up after a session of DF. This is the first study to compare the effects of both techniques on the mechanical properties of the teres major muscle after an intervention and at one-week of follow-up. No statistically significant differences were found in teres major muscle stiffness and tone after a single session of DN or DF. Regarding the within-groups change scores, the results of both groups did not reach the MDCs.

No statistically significant between-group differences were found in pain intensity, shoulder ROM, or muscle extensibility. Previous studies have shown that both techniques are effective for decreasing pain and increasing shoulder ROM and extensibility. Ceballos-Laita et al. [7] found an improvement in pain intensity, shoulder ROM, and extensibility in elite handball athletes after a single session of ultrasound-guided DN in the teres major muscle. Barra-López et al. [13] found an improvement in shoulder ROM after a single session of DN in patients with a painful shoulder. The results of our study found that neither technique was superior to the other in patients with shoulder pain and GIRD. The within-group analysis showed that the change scores of both groups at both timepoints achieved higher values than the SEMs and MDCs described for all the secondary outcomes except for extensibility in the DN group.

From a clinical point of view, a higher muscle stiffness and/or a lack of muscle extensibility have shown to be linked with a restricted ROM [38]. Multiple interventions have been applied to the posterior shoulder muscles in order to decrease its stiffness or improve its extensibility such as manual therapy [39], muscle stretching [40], muscle energy techniques [41], taping and kinesiotaping [42,43], or DN [44]. All of them found improvements in pain intensity and/or shoulder ROM, exposing a relationship between the posterior shoulder muscles and shoulder ROM. In this case, we compared an invasive intervention to a conservative intervention to change the mechanical properties of the teres major muscle, pain intensity, shoulder ROM, and muscle extensibility but neither achieved better results than the other, so no recommendation can be made.

This study presents some limitations. First, only one treatment session was applied, and the outcome measures were registered over a short-term follow-up period (one week). So, no medium- or long-term outcomes were assessed. Secondly, only male elite handball athletes were included in the study and therefore cannot represent all overhead athletes, so these results cannot be extrapolated to other genders or populations. Third, the patient status covered acute and chronic phases due to the wide range of time from the onset of symptoms, which may have influenced the results. Future studies should determine the medium- and long-term outcomes of both treatment techniques, and combinations with other conservative therapies in male and female overhead athletes.

## 5. Conclusions

The results found for the muscle stiffness and muscle tone of the teres major muscle after the application of the DN technique or the DF technique were similar after the intervention and at one-week follow-up and did not exceed the MDCs. Concerning the secondary outcomes, both groups achieved changes higher than the MDCs for shoulder ROM but without statistically significant differences between them at any timepoint. Thus, DN and DF seem to be effective interventions to modulate pain and improve shoulder ROM in handball athletes with shoulder pain and GIRD but not to modify the mechanical properties of the teres major muscle.

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**Data Availability Statement:** The reported data results are not available.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

1. Raya-González, J.; Clemente, F.M.; Beato, M.; Castillo, D. Injury profile of male and female senior and youth handball players: A systematic review. *Int. J. Environ. Res. Public Health* **2020**, *17*, 3925. [CrossRef]
2. Ceballos-Laita, L.; Pérez-Manzano, A.; Mingo-Gómez, T.; Hernando-Garijo, I.; Medrano-De-La-Fuente, R.; Estébanez-de-Miguel, E.; Jiménez-del-Barrio, S. Range of motion and muscle function on shoulder joints of young handball athletes. *J. Back Musculoskelet. Rehabil.* **2021**, *35*, 161–167. [CrossRef]
3. Wilk, K.E.; MacRina, L.C.; Fleisig, G.S.; Porterfield, R.; Simpson, C.D.; Harker, P.; Paparesta, N.; Andrews, J.R. Correlation of glenohumeral internal rotation deficit and total rotational motion to shoulder injuries in professional baseball pitchers. *Am. J. Sports Med.* **2011**, *39*, 329–335. [CrossRef] [PubMed]
4. Burkhart, S.S.; Morgan, C.D.; Kibler, W.B. The disabled throwing shoulder: Spectrum of pathology Part I: Pathoanatomy and biomechanics. *Arthrosc. J. Arthrosc. Relat. Surg.* **2003**, *19*, 404–420. [CrossRef]
5. Burkhart, S.S.; Morgan, C.D.; Kibler, W.B. The disabled throwing shoulder: Spectrum of Pathology Part II: Evaluation and treatment of SLAP lesions in throwers. *Arthrosc. J. Arthrosc. Relat. Surg.* **2003**, *19*, 531–539. [CrossRef]
6. Almeida, G.P.L.; Silveira, P.F.; Rosseto, N.P.; Barbosa, G.; Ejnisman, B.; Cohen, M. Glenohumeral range of motion in handball players with and without throwing-related shoulder pain. *J. Shoulder Elb. Surg.* **2013**, *22*, 602–607. [CrossRef]
7. Ceballos-Laita, L.; Medrano-De-la-fuente, R.; Estébanez-De-miguel, E.; Moreno-Cerviño, J.; Mingo-Gómez, M.T.; Hernando-Garijo, I.; Jiménez-Del-barrio, S. Effects of dry needling in teres major muscle in elite handball athletes. A randomised controlled trial. *J. Clin. Med.* **2021**, *10*, 4260. [CrossRef] [PubMed]
8. Fieseler, G.; Jungermann, P.; Koke, A.; Irlenbusch, L.; Delank, K.S.; Schwesig, R. Range of motion and isometric strength of shoulder joints of team handball athletes duringthe playing season, part II: Changes after midseason. *J. Shoulder Elb. Surg.* **2015**, *24*, 391–398. [CrossRef]
9. Fieseler, G.; Jungermann, P.; Koke, A.; Irlenbusch, L.; Delank, K.S.; Schwesig, R. Glenohumeral range of motion (ROM) and isometric strength of professional team handball athletes, part III: Changes over the playing season. *Arch. Orthop. Trauma Surg.* **2015**, *135*, 1691–1700. [CrossRef]
10. Barra-López, M.E.; López-de-Celis, C.; Pérez-Bellmunt, A.; Puyalto-de-Pablo, P.; Sánchez-Fernández, J.J.; Lucha-López, M.O. The supporting role of the teres major muscle, an additional component in glenohumeral stability? An anatomical and radiological study. *Med. Hypotheses* **2020**, *141*, 109728. [CrossRef] [PubMed]
11. Jiménez-del-Barrio, S.; Jiménez-Rejano, J.J.; Rebollo-Salas, M.; Mingo-Gómez, M.T.; Lorenzo-Muñoz, A.; Ceballos-Laita, L. Increased Tone and Stiffness of the Teres Major Muscle in Elite Handball Athletes: A Cross-Sectional Study. *Appl. Sci.* **2023**, *13*, 8457. [CrossRef]

12. Barra López, M.E.; López de Celis, C.; Fernández Jentsch, G.; Raya de Cárdenas, L.; Lucha López, M.O.; Tricás Moreno, J.M. Effectiveness of Diacutaneous Fibrolysis for the treatment of subacromial impingement syndrome: A randomised controlled trial. *Man. Ther.* **2013**, *18*, 418–424. [CrossRef]
13. Barra, M.E.; López, C.; Fernández, G.; Murillo, E.; Villar, E.; Raya, L. The immediate effects of diacutaneous fibrolysis on pain and mobility in patients suffering from painful shoulder: A randomized placebo-controlled pilot study. *Clin. Rehabil.* **2011**, *25*, 339–348. [CrossRef]
14. López-de-Celis, C.; Barra-López, M.-E.; González-Rueda, V.; Bueno-Gracia, E.; Rodríguez-Rubio, P.-R.; Tricás-Moreno, J.-M. Effectiveness of diacutaneous fibrolysis for the treatment of chronic lateral epicondylalgia: A randomized clinical trial. *Clin. Rehabil.* **2018**, *32*, 644–653. [CrossRef] [PubMed]
15. Arias-Buría, J.L.; Fernández-de-las-Peñas, C.; Palacios-Ceña, M.; Koppenhaver, S.L.; Salom-Moreno, J. Exercises and Dry Needling for Subacromial Pain Syndrome: A Randomized Parallel-Group Trial. *J. Pain* **2017**, *18*, 11–18. [CrossRef]
16. Calvo-Lobo, C.; Pacheco-Da-Costa, S.; Martínez-Martínez, J.; Rodríguez-Sanz, D.; Cuesta-Álvaro, P.; López-López, D. Dry Needling on the Infraspinatus Latent and Active Myofascial Trigger Points in Older Adults with Nonspecific Shoulder Pain: A Randomized Clinical Trial. *J. Geriatr. Phys. Ther.* **2018**, *41*, 1–13. [CrossRef]
17. Arias-Buría, J.L.; Valero-Alcaide, R.; Cleland, J.A.; Salom-Moreno, J.; Ortega-Santiago, R.; Atín-Arratibel, M.A.; Fernández-De-Las-Peñas, C. Inclusion of trigger point dry needling in a multimodal physical therapy program for postoperative shoulder pain: A randomized clinical trial. *J. Manip. Physiol. Ther.* **2015**, *38*, 179–187. [CrossRef]
18. Navarro-santana, M.J.; Gómez-Chiguano, G.F.; Cleland, J.A.; Arias-Buria, J.L.; Fernández-de-las-Peñas, C.; Plaza-manzano, G. Effects of Trigger Point Dry Needling for Nontraumatic Shoulder Pain of Musculoskeletal Origin: A Systematic Review and Meta-Analysis. *Phys. Ther. Rehabil. J.* **2020**, *101*, pzaa216. [CrossRef]
19. Isabel de-la-Llave-Rincón, A.; Puentedura, E.J.; Fernández-de-las-Peñas, C. Clinical presentation and manual therapy for upper quadrant musculoskeletal conditions. *J. Man. Manip. Ther.* **2011**, *19*, 201–211. [CrossRef] [PubMed]
20. Dommerholt, J.; Mayoral del Moral, O.; Gröbli, C. Trigger Point Dry Needling. *J. Man. Manip. Ther.* **2006**, *14*, 70E–87E. [CrossRef]
21. López-De-Celis, C.; Pérez-Bellmunt, A.; Bueno-Gracia, E.; Fanlo-Mazas, P.; Zárate-Tejero, C.A.; Llurda-Almuzara, L.; Arróniz, A.C.; Rodriguez-Rubio, P.R. Effect of diacutaneous fibrolysis on the muscular properties of gastrocnemius muscle. *PLoS ONE* **2020**, *15*, e243225. [CrossRef]
22. Sánchez-Infante, J.; Bravo-Sánchez, A.; Jiménez, F.; Abián-Vicén, J. Effects of dry needling on mechanical and contractile properties of the upper trapezius with latent myofascial trigger points: A randomized controlled trial. *Musculoskelet. Sci. Pract.* **2021**, *56*, 102456. [CrossRef]
23. Simons, D.; Travell, J.G.; Simons, L. *Myofascial Pain and Dysfunction: The Trigger Point Manual*, 2nd ed.; Editorial Panamericana: Madrid, Spain, 2007.
24. Hong, C.; Torigoe, Y. Electrophysiological characteristics of localized twitch responses in responsive taut bands of rabbit skeletal muscle fibers. *J. Musculoskelet. Pain* **1994**, *2*, 17–43. [CrossRef]
25. Hong, C.Z.; Torigoe, Y. The localized twitch responses in responsive taut bands of rabbit skeletal muscle fibers are related to the reflexes at spinal cord level. *J. Musculoskelet. Pain* **1995**, *3*, 15–33. [CrossRef]
26. Ceballos-Laita, L.; Jiménez-del-Barrio, S.; Marín-Zurdo, J.; Moreno-Calvo, A.; Marín-Boné, J.; Albarova-Corral, M.I.; Estébanez-de-Miguel, E. Effectiveness of Dry Needling Therapy on Pain, Hip Muscle Strength and Physical Function in Patients With Hip Osteoarthritis: A Randomized Controlled Trial. *Arch. Phys. Med. Rehabil.* **2021**, *102*, 959–966. [CrossRef]
27. Ditroilo, M.; Hunter, A.M.; Haslam, S.; De Vito, G. The effectiveness of two novel techniques in establishing the mechanical and contractile responses of biceps femoris. *Physiol. Meas.* **2011**, *32*, 1315–1326. [CrossRef]
28. Llurda-Almuzara, L.; Pérez-Bellmunt, A.; López-de-Celis, C.; Aiguadé, R.; Seijas, R.; Casasayas-Cos, O.; Labata-Lezaun, N.; Alvarez, P. Normative data and correlation between dynamic knee valgus and neuromuscular response among healthy active males: A cross-sectional study. *Sci. Rep.* **2020**, *10*, 17206. [CrossRef] [PubMed]
29. Aird, L.; Samuel, D.; Stokes, M. Quadriceps muscle tone, elasticity and stiffness in older males: Reliability and symmetry using the MyotonPRO. *Arch. Gerontol. Geriatr.* **2012**, *55*, e31–e39. [CrossRef]
30. Tashjian, R.Z.; Deloach, J.; Porucznik, C.A.; Powell, A.P. Minimal clinically important differences (MCID) and patient acceptable symptomatic state (PASS) for visual analog scales (VAS) measuring pain in patients treated for rotator cuff disease. *J. Shoulder Elb. Surg.* **2009**, *18*, 927–932. [CrossRef]
31. Laudner, K.; Compton, B.D.; McLoda, T.A.; Walters, C.M. Acute effects of instrument assisted soft tissue mobilization for improving posterior shoulder range of motion in collegiate baseball players. *Int. J. Sports Phys. Ther.* **2014**, *9*, 1–7.
32. Lim, J.Y.; Kim, T.H.; Lee, J.S. Reliability of measuring the passive range of shoulder horizontal adduction using a smartphone in the supine versus the side-lying position. *J. Phys. Ther. Sci.* **2015**, *27*, 3119–3122. [CrossRef] [PubMed]
33. Tyler, T.F.; Roy, T.; Nicholas, S.J.; Gleim, G.W. Reliability and validity of a new method of measuring posterior shoulder tightness. *J. Orthop. Sport. Phys. Ther.* **1999**, *29*, 262–274. [CrossRef] [PubMed]
34. Tyler, T.F.; Nicholas, S.J.; Roy, T.; Gleim, G.W. Quantification of posterior capsule tightness and motion loss in patients with shoulder impingement. *Am. J. Sports Med.* **2000**, *28*, 668–673. [CrossRef]
35. Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*; Hillsdale, N., Ed.; Lawrence Erlbaum Associates Publishers: Mahwah, NJ, USA, 1988; ISBN 9781483276489.

36. Mcnair, P.J.; Dombroski, E.W.; Hewson, D.J.; Stanley, S.N. Stretching at the ankle joint: Viscoelastic responses to holds and continuous passive motion. *Med. Sci. Sport. Exerc.* **2001**, *33*, 354–358. [CrossRef] [PubMed]
37. Davidoff, R.A. Skeletal muscle tone and the misunderstood stretch reflex. *Neurology* **1992**, *42*, 951–963. [CrossRef] [PubMed]
38. Hung, C.J.; Hsieh, C.L.; Yang, P.L.; Lin, J.J. Relationship between posterior shoulder muscle stiffness and rotation in patients with stiff shoulder. *J. Rehabil. Med.* **2010**, *42*, 216–220. [CrossRef]
39. Lluch, E.; Pecos-Martín, D.; Domenech-García, V.; Herrero, P.; Gallego-Izquierdo, T. Effects of an anteroposterior mobilization of the glenohumeral joint in overhead athletes with chronic shoulder pain: A randomized controlled trial. *Musculoskelet. Sci. Pract.* **2018**, *38*, 91–98. [CrossRef]
40. Albertin, E.S.; Miley, E.N.; May, J.; Baker, R.T.; Reordan, D. Effectiveness of stretching on posterior shoulder tightness and glenohumeral internal rotation deficit: A systematic review of randomised controlled trials. *J. Sport Rehabil.* **2018**, *29*, 622–627.
41. Moore, S.D.; Laudner, K.G.; Mcloda, T.A.; Shaffer, M.A. The immediate effects of muscle energy technique on posterior shoulder tightness: A randomized controlled trial. *J. Orthop. Sports Phys. Ther.* **2011**, *41*, 400–407. [CrossRef]
42. Lo, C.-L.; Hsueh, Y.-H.; Wang, C.-H.; Chang, H.-Y. Comparison of the Acute Effects of Kinesio Taping and Sleeper Stretching on the Shoulder Rotation Range of Motion, Manual Muscle Strength, and Sub-Acromial Space in Pitchers with Glenohumeral Internal Rotation Deficit. *Medicina* **2021**, *57*, 102. [CrossRef]
43. Gulpinar, D.; Ozer, S.T.; Yesilyaprak, S.S. Effects of rigid and kinesio taping on shoulder rotation motions, posterior shoulder tightness, and posture in overhead athletes: A randomized controlled trial. *J. Sport Rehabil.* **2019**, *28*, 256–265. [CrossRef] [PubMed]
44. Kamali, F.; Sinaei, E.; Morovati, M. Comparison of Upper Trapezius and Infraspinatus myofascial trigger point therapy by dry needling in overhead athletes with unilateral shoulder impingement syndrome. *J. Sport Rehabil.* **2018**, *29*, 622–627. [CrossRef] [PubMed]