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Gross Anatomical Study on the Application of Humeral Bony Landmarks for Shoulder Pain Recovery in Greco-Roman Wrestlers and Cases Involving the Articular Branches of the Glenohumeral Joint

Estudio Anatómico Macroscópico Sobre la Aplicación de Referencias Óseas Humerales para la Recuperación del Dolor de Hombro en Luchadores Grecorromanos y Casos que Involucran las Ramas Articulares de la Articulación Glenohumeral

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SUMMARY: This study investigated the effects of a targeted shoulder intervention on pain and rotational mobility in Greco-Roman wrestlers and examined the anatomical characteristics of articular nerve branches supplying the glenohumeral joint. Twenty wrestlers with shoulder discomfort underwent an intervention involving manual pressure applied to the greater tubercle, lesser tubercle, and coracoid process combined with active shoulder movements. Shoulder medial and lateral rotation angles were measured using a goniometer, and pain and movement discomfort were assessed using a visual analog scale before and after the intervention. Additionally, detailed dissections of twelve embalmed cadavers were performed to identify the origin and course of articular branches from the brachial plexus. Following the intervention, pain scores markedly decreased, medial rotation was reduced, and lateral rotation increased. Anatomical analysis revealed a long and independently coursing articular branch arising from the posterior cord of the brachial plexus and supplying the glenohumeral joint. Owing to its prolonged and isolated course, this branch may be susceptible to entrapment or mechanical irritation caused by hypertrophied or structurally altered surrounding musculature, potentially contributing to shoulder pain in wrestlers. These findings suggest that targeted pressure combined with active movement may improve shoulder pain and mobility through mechanical and neurophysiological mechanisms.

KEY WORDS: Shoulder pain; Wrestler; Anatomical study; Bony landmark.

INTRODUCTION

Greco-Roman wrestling athletes are particularly prone to upper-body musculoskeletal pain and injuries, most notably in the shoulder and cervical spine (Goodman *et al*., 2018). In all wrestling styles, the match begins in a standing or neutral position on the mat, and the primary objective is to subdue the opponent by pressing both shoulders to the ground (Bakhsh & Nicandri, 2018). Points can be awarded either by achieving a fall, in which the opponent's shoulders are held against the mat for at least two seconds, or by gaining positional advantage and control. In the parterre position, which is used to defend against an opponent's attack, both hands and knees must be fixed on the mat while the torso is maintained as close to the floor as possible (Cools *et al*., 2007).

During execution of the fall and split positions, sufficient mobility of the glenohumeral joint is required, and the elbow joint must allow free abduction and internal rotation (Marieb & Hoehn, 2007). Therefore, glenohumeral joint range of motion (ROM) is an important factor for maintaining effective fall and parterre positions in wrestling (Adams *et al*., 2016); however, these demands place substantial mechanical stress on the shoulder, often accompanied by pain.

In wrestling, the glenohumeral joint plays a critical role in scoring maneuvers and is anatomically formed by the articulation of three bones, with dynamic control provided by the rotator cuff musculature. The supraspinatus, infraspinatus, pectoralis minor, and subscapularis collectively contribute to both stability and movement of the joint, and impairments such as muscle weakness or excessive tightness can negatively affect athletic performance (Parsons *et al*., 2002). These muscles insert across a broad and structurally distinct area of the humeral head, where mechanical loads generated during activity are transferred from muscle to bone

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via the tendons. As a result, repeated fatigue and loading concentrate stress at these insertion sites, rendering them vulnerable to injury. When rotator cuff muscle length or strength is inadequate, resistance to external forces is diminished, thereby increasing susceptibility to damage of the greater and lesser tubercles of the humerus (Karduna *et al*., 1996).

In wrestlers, the occurrence of shoulder injuries is strongly related to limitations in glenohumeral joint range of motion (ROM). Although injury to the supraspinatus is most frequently reported, shoulder pain can also arise from surrounding musculature, including the coracobrachialis, the short head of the biceps brachii, and the pectoralis minor (Saha, 1971; Labriola *et al*., 2005). The supraspinatus inserts into the greater tubercle of the humerus and contributes substantially to rotational control of the glenohumeral joint. Pathological changes such as muscle shortening or tearing impair joint stability, thereby elevating the risk of dislocation and causing secondary weakness in the deltoid and other rotator cuff muscles enveloping the humerus (Cools *et al*., 2007; Marieb & Hoehn, 2007). Consequently, both glenohumeral joint ROM and the functional status of periarticular muscles play a crucial role in the effective performance of wrestling techniques (Steenbrink *et al*., 2009).

Upper limb injuries have been shown to occur far more frequently during wrestling matches than during training sessions, with competitive injury rates reported to be nearly 2.5 times higher. Additionally, the likelihood of injury decreases as the level of athletic experience increases (a). Research investigating recovery from shoulder injuries in athletes indicates that only a small proportion of cases (5.9 %) necessitate surgical management, while the majority (88.9 %) successfully return to sport following rehabilitation-based or conditioning interventions (Collin *et al*., 2014). Evidence from previous studies emphasizes that rehabilitation strategies for shoulder injuries in wrestlers, should prioritize restoration of mobility and alleviation of fibrotic tissue restrictions. In particular, shoulder movement exercises have demonstrated therapeutic benefits by stimulating the surrounding connective tissues, such as muscles, tendons, and ligaments, thereby promoting functional recovery (McMillian *et al*., 2006; Polat *et al*., 2018).

Furthermore, numerous studies recommend flexibility training and shoulder rotation exercises aimed at improving internal rotation angle as conservative treatment following shoulder injury, both to prevent secondary injuries and to support recovery. These rehabilitation exercises are considered essential even after surgical treatment (McMillian *et al*., 2006). This evidence suggests that most injuries sustained during competition can be effectively managed and allow for rapid return to play through non-surgical interventions (Adams *et al*., 2016; Kilit *et al*., 2019). Recent studies have demonstrated that the application of appropriately controlled pressure to specific bony landmarks of the shoulder, including the lesser tubercle, greater tubercle, and coracoid process, is effective in promoting recovery in wrestlers. This approach is therefore considered an important strategy in shoulder rehabilitation and conditioning (Yoon *et al*., 2024).

Tissues such as bone attachment sites, ligaments, and tendons are characteristically pale in appearance, reflecting their high collagen fiber content. Due to their fibrous composition, these tissues undergo minimal dimensional change during contraction and relaxation, and from a circulatory perspective, they are considered relatively less perfused and prone to stagnation. Therefore, applying physical pressure to these tissues while performing movement is hypothesized to enhance local circulation, thereby exerting beneficial effects on tissue recovery and blood flow.

Recent anatomical studies have demonstrated that the neural innervation of the glenohumeral joint is more complex than traditionally described, involving multiple articular branches arising from the brachial plexus. While the suprascapular and axillary nerves are commonly recognized as the primary contributors to glenohumeral joint sensation, cadaveric investigations have identified additional articular branches originating from regions of the brachial plexus, including fibers associated with the posterior cord, that supply periarticular structures such as the joint capsule and subdeltoid bursa (Seo *et al*., 2018; Laumonerie *et al*., 2020). These articular branches are believed to convey nociceptive and proprioceptive information, thereby playing a role in both pain perception and neuromuscular control of shoulder movement (Laumonerie *et al*., 2020). Alterations or mechanical irritation of these neural pathways may contribute to shoulder pain and movement dysfunction, particularly in athletes exposed to repetitive loading and high-contact forces, such as Greco-Roman wrestlers (Seo *et al*., 2018). Accordingly, understanding the anatomical distribution and functional significance of these articular neural branches may provide important insight into the mechanisms underlying shoulder pain and impaired movement, as well as inform targeted rehabilitation and conditioning strategies.

Therefore, the purpose of the present study was twofold: first, to investigate the effects of improvements in pain and movement on shoulder condition in Greco-Roman wrestling athletes; and second, to examine the anatomical characteristics of the articular branches to the glenohumeral joint by performing detailed dissections of the shoulder region in twelve cadavers, with particular attention to identifying distinctive neural patterns arising from the brachial plexus.

MATERIAL AND METHOD

Greco-Roman wrestling athletes with a history of shoulder pain were recruited for the clinical portion of the study. A total of twenty athletes who reported even mild shoulder discomfort or a subtle sense of abnormal or less-than-optimal shoulder movement compared with their usual condition were included in the study.

Manual pressure was applied to the regions surrounding the lesser tubercle, greater tubercle, and coracoid process of the shoulder using the examiner's hand or a massage ball or baseball. While maintaining pressure on these anatomical landmarks, participants performed active shoulder movements, including rotation, flexion, and extension, with 50 repetitions for each movement. Shoulder medial and lateral rotation angles were measured before and after the intervention using a goniometer, and changes in these values were recorded for analysis. Pain intensity was assessed using a visual analog scale (VAS) before and after the intervention. Shoulder medial and lateral rotation angles were measured by the examiner using a goniometer, with the axis aligned over the humerus to quantify the angular displacement of glenohumeral joint movement.

For the anatomical investigation, twelve human cadavers (24 shoulders) were used. All specimens were free from visible deformity, surgical scars, or traumatic injury to the shoulder region. Dissections were performed in accordance with standard anatomical protocols. The skin and superficial fascia were removed, followed by careful reflection of the deltoid and surrounding musculature to expose the brachial plexus and its branches (Figs. 1 and 2).

Special attention was given to tracing neural branches arising from the brachial plexus, particularly those associated with the posterior cord. Articular branches supplying the glenohumeral joint capsule, periarticular connective tissues, and subdeltoid bursa were identified, documented, and photographed. The course, origin, and distribution patterns of these branches were recorded to identify anatomical variations or distinctive neural configurations.

The clinical study protocol was approved by the institutional review board, and all procedures involving human participants conformed to the principles outlined in the Declaration of Helsinki. Cadaveric specimens were obtained through a legally authorized body donation program, and all dissections were conducted in accordance with institutional ethical guidelines for anatomical research.

Descriptive statistics were calculated for all clinical variables. Changes in shoulder pain and ROM before and after the intervention were analyzed using appropriate statistical tests. Statistical significance was set at $p < 0.05$. All analyses were performed using standard statistical software.

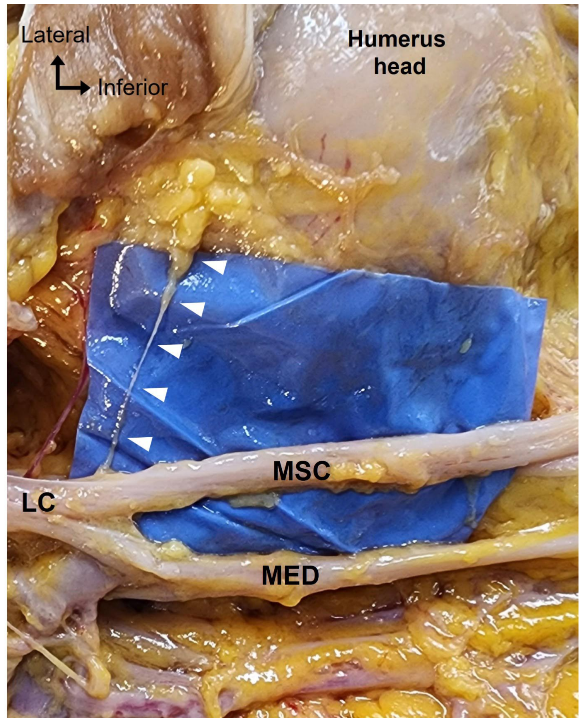

Fig. 1. The articular branch originating from the lateral cord of the branchial plexus. LC, lateral cord; MSC, musculocutaneous nerve; MED, median nerve; arrow head, articular branch.

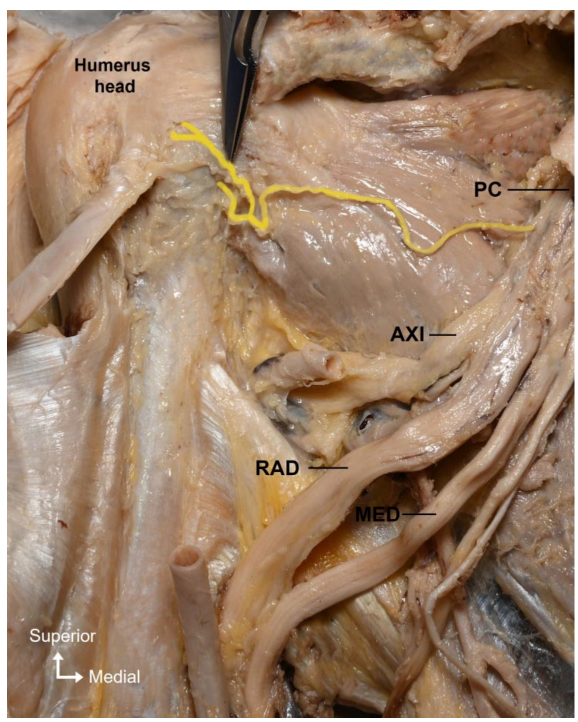

Fig. 2. A long and independent articular branch arising from the proximal part of the posterior cord of the brachial plexus. PC, posterior cord; AXI, axillary nerve; RAD, radial nerve; MED, median nerve; yellow color, articular branch.

RESULTS

In this study, the VAS score was used to assess not only pain intensity but also the degree of shoulder stiffness and perceived movement discomfort or abnormality. Following the application of pressure to the regions surrounding the greater tubercle, lesser tubercle, and coracoid process combined with active movement, the mean VAS score decreased from 5.8 before the intervention to 1.3 after the intervention (Table I).

The mean shoulder medial rotation angle was 27.2° before the intervention and decreased to 22.6° after the intervention. In contrast, the mean lateral rotation angle increased from 147.3° before the intervention to 159.6° after the intervention (Table I).

Table I. Pre and post intervention Visual Analog Scale (VAS) scores and glenohumeral joint medial and lateral rotation angles.

Variable	Pre	Post
VAS	5.8 ± 1.4	1.3 ± 0.4
Medial rotation (°)	27.2 ± 3.5	22.6 ± 2.7
Lateral rotation (°)	147.3 ± 14.5	159.6 ± 8.9

In the cadaveric investigation, an articular branch coursing from the lateral cord to the glenohumeral joint was identified in three specimens (Fig. 1). In addition, one specimen exhibited a distinctive and atypical branching pattern. Anatomical dissection revealed a long and independent articular branch supplying the glenohumeral joint originating from the posterior cord of the brachial plexus. This nerve did not divide into the musculocutaneous and median nerves but instead coursed as a single trunk, giving rise to muscular branches to the coracobrachialis and biceps brachii muscles. Notably, a distinct articular branch traveling proximally toward the glenohumeral joint and an additional branch supplying the sheath of the long head of the biceps brachii were identified proximal to these muscular branches (Fig. 2).

DISCUSSION

The present study investigated changes in shoulder pain, movement discomfort, and rotational mobility in Greco-Roman wrestling athletes following a targeted intervention, and further explored the anatomical basis underlying these clinical findings through cadaveric dissection. The primary findings included a marked reduction in VAS scores, a decrease in medial rotation angles, and an increase in lateral rotation angles after the intervention, along with the identification of a long and distinct articular nerve branch to the glenohumeral joint arising from the posterior cord of the brachial plexus (Table I; Fig. 1).

The substantial reduction in VAS scores observed in this study suggests that the applied intervention was effective in alleviating not only shoulder pain but also perceived stiffness and abnormal movement sensation. In this study, the VAS encompassed both pain intensity and subjective movement discomfort, which reflects the functional complaints frequently reported by wrestlers exposed to repetitive loading and sustained isometric demands around the glenohumeral joint (Bahr & Krosshaug, 2005; Yoon *et al*., 2024). Previous studies have demonstrated that manual pressure combined with active movement can facilitate local circulation, reduce periarticular tissue tension, and modulate nociceptive input from joint-related structures, thereby contributing to pain reduction and improved movement quality (Schleip, 2003; Bialosky *et al*., 2009). In the present study, some athletes demonstrated a relatively slower improvement in pain despite the absence of abnormal findings on routine clinical evaluation. This raised questions regarding the origin of their shoulder pain. Considering the anatomical finding of a long and independently coursing articular branch supplying the glenohumeral joint, it is possible that such a neural configuration may contribute to persistent or atypical pain patterns. Given the well-developed musculature and frequent shoulder use characteristic of Greco-Roman wrestling athletes, it is conceivable that the anatomical variation identified in the cadaveric study may be present in this athletic population and could partially explain the delayed pain improvement observed in certain individuals.

With respect to shoulder rotational mobility, medial rotation angles decreased whereas lateral rotation angles increased following the intervention. Greco-Roman wrestling is characterized by repetitive anterior loading of the shoulder girdle, which often results in increased internal rotation tone and restriction of external rotation (Astolfi *et al*., 2015). Improvements in external rotation range of motion have been associated with enhanced shoulder function and a reduced risk of injury in overhead and contact athletes (Wilk *et al*., 2009; López-Laval *et al*., 2022). The observed increase in lateral rotation in the present study may therefore indicate a favorable adaptation toward a more functional shoulder movement pattern. In addition to improvements in pain-related outcomes, the enhancement of smooth and coordinated shoulder movement observed in this study may contribute positively to injury prevention in athletes by reducing excessive mechanical stress on the glenohumeral joint during repetitive and high-load activities.

The anatomical findings of this study provide a potential neuroanatomical explanation for the observed clinical outcomes. Cadaveric dissection revealed a long and independent articular branch to the glenohumeral joint originating from the posterior cord of the brachial plexus (Fig. 2). Previous anatomical studies have reported that articular branches supplying the glenohumeral joint may arise from multiple sources within the brachial plexus and contribute to nociceptive and proprioceptive signaling from the joint capsule and periarticular tissues (Laumonerie *et al*., 2020). The identification of an articular branch traveling proximally toward the glenohumeral joint, as well as a branch supplying the sheath of the long head of the biceps brachii, suggests a close anatomical relationship between neural structures and commonly implicated pain-generating tissues in shoulder pathology (Seo *et al*., 2018). The independently coursing, long articular nerve branch originating from the proximal portion of the posterior cord identified in this study may possess a morphological predisposition to entrapment, particularly given the sport-specific demands of Greco-Roman wrestling, which impose substantial and repetitive mechanical loading on the glenohumeral joint.

Taken together, the clinical and anatomical findings of this study suggest that targeted pressure applied to specific shoulder bony landmarks, combined with active movement, may influence shoulder pain and rotational mobility through both mechanical and neurophysiological mechanisms. These findings emphasize the importance of considering periarticular neural structures, in addition to muscular and connective tissues, when developing rehabilitation and conditioning strategies for Greco-Roman wrestling athletes. Further studies with larger sample sizes and objective neurophysiological measures are required to clarify the functional role of these articular branches in shoulder pain modulation and movement control.

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KIM, B. H. & JEON, A. Estudio anatómico macroscópico sobre la aplicación de referencias óseas humerales para la recuperación del dolor de hombro en luchadores grecorromanos y casos que involucran las ramas articulares de la articulación glenohumeral. *Int. J. Morphol., 44(3)*:888-893, 2026.

RESUMEN: Este estudio investigó los efectos de una intervención específica en el hombro sobre el dolor y la movilidad rotacional en luchadores grecorromanos y examinó las características anatómicas de las ramas nerviosas articulares que inervan la articulación glenohumeral. Veinte luchadores con molestias en el hombro se sometieron a una intervención que consistió en la aplicación de presión manual en el tubérculo mayor, el tubérculo menor y el proceso coracoides, combinada con movimientos activos del hombro. Se midieron los ángulos de rotación medial y lateral del hombro con un goniómetro, y se evaluó el dolor y las molestias durante el movimiento mediante una escala analógica visual antes y después de la intervención. Además, se realizaron disecciones detalladas de doce cadáveres embalsamados para identificar el origen y el trayecto de las ramas articulares del plexo braquial. Tras la intervención, las puntuaciones de dolor disminuyeron notablemente, la rotación medial se redujo y la rotación lateral aumentó. El análisis anatómico reveló un ramo articular largo e independiente que se originaba en el fascículo posterior del plexo braquial e inervaba la articulación glenohumeral. Debido a su recorrido prolongado y aislado, este ramo puede ser susceptible a la compresión o irritación mecánica causada por la musculatura circundante hipertrofiada o con alteraciones estructurales, lo que podría contribuir al dolor de hombro en luchadores. Estos hallazgos sugieren que la presión dirigida combinada con el movimiento activo puede mejorar el dolor y la movilidad del hombro mediante mecanismos mecánicos y neurofisiológicos.

PALABRAS CLAVE: Dolor de hombro; Luchador; Estudio anatómico; Punto de referencia óseo.

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