

## **Online Resource 2 Systematic review**

### **Review Title:**

Modifiable musculoskeletal factors and their association with shoulder function in adults: A Systematic review of Etiology and Risk.

### **Journal: Discover Medicine**

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41 Table 1: Table of Characteristics of Included Studies  
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| Study                   | Country  | Setting/context                         | Participant characteristics                                                                                                                                                                                                                                                        | Groups                                          | Outcomes measured                                                                                                                           | Main description of results                                                                                                                                    |
|-------------------------|----------|-----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Umehara et al., 2017.   | Japan    | University setting                      | Men (n=18).<br>Age:26.2 (4.0) years.<br>Height: 171.1 (5.0) cm.<br>Weight: 67.4 (7.8) kg.                                                                                                                                                                                          | One group.                                      | (PM) length applying shear elastic modulus, used as the index of muscle elongation, was computed using ultrasonic shear wave elastography . | The most effective stretching position for PM was determined to be horizontal abduction at an elevation of 90 degrees and horizontal abduction at 150 degrees. |
| Harrington et al., 2014 | Brittan. | British Swimming World Class programme. | Female: (n = 37).<br>Age = 19.5 (1.19) years.<br>Height = 170 (7) cm.<br>Weight = 64.7 (6.8) kg.<br>Body-mass index = 22.5 (2.3) kg/m <sup>2</sup> , who were at least 18 years old, currently participating in full team practices, and had no history of shoulder surgery in the | Two groups<br>Painful versus non-painful group. | IR and ER ROM; PML; JPS 45-degree angle; lateral rotation.                                                                                  | Following swimming training shoulder external rotation range of motion and pectoralis minor length reduced significantly in the painful group.                 |

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46 *Table 2: Characteristics of Included Studies - Case Control Study Form*

| Study                | Country | Setting/context        | Participant characteristics                                                                                 | Group A description and sample                                          | Group B description and sample   | Exposures/variables measured                                                                                                                                                                                                                                                                                                                                                                                     | Description of main results                                                                                                                                                                                                                                                        |
|----------------------|---------|------------------------|-------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Verm a et al., 2020. | Rohtak. | Sample of convenience. | N= 181. N= 90 (F), n= 91 (M). Patients aged between 30-70 years. Two groups age and gender matched control. | 181 Randomly selected cases with shoulder pain, age and gender matched. | 181 Cases without shoulder pain. | Hand dominance, activity level, working above shoulder level>1 hour, lifting heavy objects > 2 hours, sleep quality, sleep duration, distress, depression, somatisation, waist hip ratio, measures of serum lipid profile, (triglyceride, cholesterol, LDL and VLDL), C-reactive protein, diabetes, metabolic syndrome, pectoralis minor tightness, thoracic kyphosis, antagonist strength ratio (flexion/extens | The final prediction model showed that six out of nine principal components significantly predicted shoulder pain: 1. shoulder compromising work situations; 2. lipid profile I; 3. sleep function; 4. metabolic disorders; 5. antagonist strength ratio; and 6. thoracic posture. |

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|                                   |              |                                  |                                                                                                                                                                                                                                          |                                                                         |                                                                                | ion, abduction/adduction, external rotation/internal rotation) and presence of neck pain.                                                                                                                         |                                                                                                                                                                                    |
| Castel<br>ein et<br>al.,<br>2016. | Belgiu<br>m. | Laborator<br>y control<br>study. | N= 37 (F).<br>SIS group<br>(n = 17)<br>Control<br>group (n =<br>20)<br>Height:<br>167.4<br>(6.1) cm<br>170.1<br>(5.9) cm;<br>Weight:<br>65.7 (9.4)<br>kg 62.9<br>(7.1kg)<br>Age:<br>30.1<br>(10.3)<br>years,<br>28.9<br>(11.5)<br>years. | Two<br>groups<br>the SIS<br>group and<br>the asymp<br>tomatic<br>group. | The<br>healthy<br>control<br>group<br>consiste<br>d of 20<br>participa<br>nts. | EMG data was<br>collected using<br>a TeleMyo<br>2400 G2<br>Telemetry<br>System<br>(Noraxon Inc.,<br>Scottsdale,<br>AZ) from 5<br>scapulothoraci<br>c muscles<br>(Trapezius<br>(UT, MT, LT)<br>SA, LS, PM,<br>RM). | During<br>the<br>elevation<br>exercises,<br>the PM<br>was<br>significan<br>tly more<br>active in<br>the SIS<br>group in<br>compariso<br>n with the<br>healthy<br>control<br>group. |

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49 *Table 3: Characteristics of Included Studies - Diagnostic Test Accuracy Form*

| Study | Count<br>ry | Setting/con<br>text | Year/timefr<br>ame for<br>data<br>collection | Participan<br>t<br>characteri<br>stics | Index test<br>descriptio<br>n and<br>sample | Reference<br>test<br>descriptio<br>ns and<br>samples | Descripti<br>on of<br>main<br>results<br>(includin<br>g adverse<br>events<br>from<br>tests) |
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| Borstad et al., 2015 | USA. | Overhead throwing sports and non-throwing sports. | Study 1: 13 participants : once off testing.<br>Study 2: 18 participants : pre-post pitching testing.<br>Study 3: 25 participants : once off testing. | Study 1 Throwers Age=22.2 (1.4) years.<br>Height=1.79 (0.05) m.<br>Weight=79.6 (9.9) kg.<br>(n=13) M (n=4) F.<br>Non-throwers Age=23.5 (1.3) years.<br>Height=1.75 (0.06) m.<br>Weight=72.4 (7.6) kg.<br>(n=13) M (n=5) F.<br>Study 2: Age=24.2 (2.4) years.<br>Height=1.82 (0.06) m.<br>Weight=88.9 (4.7) kg.<br>(n=18) M. (n=0) F<br>Study 3: Age=36.2 (11.3) years.<br>Height=1.76 (0.07) m. | LF-low flexion test. The LF measurement is performed by passively flexing the patients' shoulder to 60 degrees in the sagittal plane, supporting the elbow, and allowing GHJ IR ROM to reach the end of passive motion. e (Borstad and Dashottar, 2011). | Horizontal adduction was measured inside lying as described by Tyler using a metal ruler marked in millimetres. | Excellent intra-rater reliability for LF (low flexion) was concluded that all ICCs were greater than 0.90, indicating excellent intra-rater reliability for LFT. The Low Flexion (LF) test position generated high strain on the posterior capsule and was responsive to experimental tightening of the capsule in a cadaver study, giving it strong construct validity |
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|                            |            |                                                                                 |                           | Weight=79.3 (8.2) kg. (n=25) M. (n=12) F.                                                                                                                           |                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                   | as a capsule-specific measure                                                                                                                                                                                                   |
| Lewis and Valentine, 2007. | London, UK | Orthopaedic and physical therapy out-patient department in a teaching hospital. | Once off data collection. | N= 90, n= 47 (F), n= 43 (M). Age= 32.1 (7.3) years. Height= 1.7 (0.1) m. Weight=70.4 (14.2) kg. Age=42.8 (16.6) years. Height=1.7 (0.1) m. Weight = 71.4 (11.8) kg. | Measurements were made with the subjects lying in supine. In this position the linear distance from the treatment table to the posterior aspect of the acromion was measured on two occasions (separated by a minimum of 30 minutes and additional data collection on other subjects to reduce bias) by one rater. | As described by Sahrmann the subjects placed their arms by their sides and the elbows were flexed and rested against the lateral wall of the abdomen. The subject's hands rested gently on the abdomen which would have placed the glenohumeral joint in slight internal rotation | The pectoralis minor length test was found to have excellent intra-rater reliability for dominant and non-dominant side of the subjects without symptoms, and for the pain-free and painful side of the subjects with symptoms. |

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| Study                   | Country | Setting/context                                                                   | Participant characteristics                                                                                                              | Groups                                      | Outcomes measured                                                                                                                                                                                                                                           | Description of main results                                                                                                                                                                                                                                                                                                                      |
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| Marcondes et al., 2013. | Brasil. | State Federation tennis championships in São Paulo, Brazil, during 2009 and 2011, | Forty-nine male amateur tennis players, between 19 and 33 years old. Age=26.2 (3.9) years. Height=177.3 (0.1) cm. Weight: 75.4 (5.4) kg. | Control group (n=22). Painful group (n=27). | Pain (VAS), internal and external rotation range of motion (ROM), posterior shoulder tightness. Isometric HHD strength using a handheld dynamometer (Lafayette Instrument Company, Lafayette, IN, USA). ROM was collected using a rigid plastic goniometer. | When the strength analyses were performed, we only observed a significant difference ( $p<0.05$ ) for the external rotation in the PG (dominant versus nondominant shoulders), indicating a weakness of the external rotators in the painful dominant shoulder. Painful Group presented lower internal rotation ROM and larger external rotation |

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|                       |                   |                                                                      |                                                                                                                                                                  |                                                           |                                                                                                                                                                                                         | ROM than the other shoulders,                                                                                                                                                         |
| Heck et al., 2021     | Florida, USA.     | University of Florida University of Florida women's gymnastics team. | N = 15 (F).<br>Age= 20.5 (0.9) years.<br>Weight=62.1 (8.6) kg.<br>Height=1.6 (0.06) m.<br>BMI= kg/m <sup>2</sup> 24.27 ± 3.5<br>Hand dominance= Right 11 Left 4. | Non-injured arm of gymnast versus injured arm of gymnast. | Isokinetic shoulder internal and external rotation strength was collected using an isokinetic dynamometer. Isometric middle and lower trapezius strength was collected using a HHD (Hoggan Microfet 2). | Preseason upper extremity ROM and strength were not different between gymnasts who sustained an in-season upper extremity overuse injury and those who did not.                       |
| Kolbert et al., 2014. | Orlando, Florida. | Weight training fraternity.                                          | N= 55 (M).<br>Age=28.3 (6.5) years;29.0 (6.1); years;<br>27.9 (6.9) years.                                                                                       | Two groups. SIS group and control group.                  | The painful arc sign and the Hawkins-Kennedy test.                                                                                                                                                      | Avoiding performance of lateral deltoid raises and upright rows beyond an angle of 90 degrees and efforts to strengthen the external rotators may serve as a useful means to mitigate |

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|                      |                          |                                                                    |                                                                                                                                                                                                   |                                               |                                                                                                                                                                                                                                             | characteristics associated with SIS.                                                                                                                                                                         |
| Miller et al., 2016. | Nashville.               | Orthopaedic and physiatry clinics at two academic medical centres. | N= 179 Participants. N=86 (F), n=93 (M). Age: 45 years and older and shoulder symptoms for at least 4 weeks. The average age was 62.7 years in patients with tear versus 59.6 years without tear. | Two groups. Symptomatic versus asymptomatic.  | Isometric shoulder contraction strength was assessed in three planes - abduction, external rotation and internal rotation using an HHD. VAS collected for pain measurement.                                                                 | Patients with supraspinatus tear had decreased abduction strength and decreased external rotation strength.                                                                                                  |
| Dutton et al., 2019. | Cape Town, South Africa. | Elite South African cricketers.                                    | Male: (n = 105). Injured (n = 18). Uninjured (n = 87). Age =27 (4.2) years, 27.5 (3.9) 26.5 (4.2). Dominance: Left= 17 2. Right=15.                                                               | Injured shoulders versus uninjured shoulders. | Shoulder function questionnaire specific to overhead athletes. Isometric muscle strength of the upper trapezius (UT), serratus anterior (SA), lower trapezius (LT), GH internal (GHIR) and external (GHER) rotators and gluteus medius (GM) | The primary outcome of this study was that cricketers do not present with the classic "thrower's paradox." Specifically, they exhibited no ERG; scapula downward rotation from rest to 90 degrees elevation; |

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|  |  |  |  |  | <p>muscles was collected using the (MicroFET 2, Hoggan Scientific, LCC., Salt Lake City, Utah, USA). A Digital inclinometer (Digi-Pas DWL80E, Digipas Technologies , Inc., Dundee, England) for collection of GH and hip rotation, scapula upward rotation and GH horizontal adduction ROM (PSC stiffness), For PM length A calliper (Mastercraft Vernier Calliper, Mastercraft Tools, Johannesburg, South Africa) was used. Diagnostic US (M7, Shenzen</p> | <p>strong LT; and maintenance of the AHD. In addition, greater GIRD and loss of total GH rotational ROM; weaker SA, GHIR and GHER; and substantially shorter PSC and PML GH and hip rotation GH horizontal adduction ROM (PSC).</p> |
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|             |               |                  |                                                       |                                                                                                                                                                                                                                                                                             | Mindray Biomedical electronics Co., Ltd., Guangdong, China) was used to. measure AHD and supraspinatus tendon thickness (SsT).                                                      |                                                                                                                                                                                                                                                                 |
| Lala. 2017. | South Africa. | Cricket players. | Thirty -six elite male cricketers, 18 years or older. | Injured: 9 cricket players sustained dominant shoulder injuries• Uninjured : 23 cricket players remained injury free• 3 excluded: 1 sustained a lumbar stress fracture, 1 sustained a non-dominant shoulder injury, 1 had a current shoulder injury during the preseason assessment and was | Shoulder external rotation ROM Shoulder internal rotation ROM Throwing arc ROM. GIRD and ERG using a bubble goniometer. Pectoralis minor length test distance a right-angled ruler. | Significant asymmetries were present between four variables in the entire group (internal rotation ROM, external rotation ROM, throwing arc ROM and pectoralis minor muscle length) and three variables in the uninjured group (internal rotation ROM, throwing |

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|                         |     |                                                                          |                                                                                                                                                                                             | not cleared to play                     |                                                                                                                                                                                                                              | arc ROM and pectoralis minor muscle length). These asymmetries may be involved in injury prevention whereas symmetries observed in the injured group may play a role in injury development during the season |
| McDonough et al., 2014. | UK. | University Sports Science Laboratory and Professional Rugby League Club. | Twenty-two professional or semi-professional rugby league players Age= 19.6 (1.77) years; 19.2 (1.59) years. Weight=93.9 (9.37) kg; 91 (10.57) kg. Height =183.6 (3.5) cm; 183.3 (1.92) cm. | Non-injured group versus injured group. | Concentric (Con) and eccentric (Ecc) peak torque values; ratio of Ecc internal rotation IR to Con external rotation ER, also known as the dynamic control ratio (DCR), shoulder range of IR and ER. An Isokinetic assessment | Injury prevention strategies for rugby league players should include exercises to improve shoulder IR and possibly Ecc IR strength.                                                                          |

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|                        |         |                                 |                                          |                                                                                                             | was carried out. on a Biodex-System III Dynamometer (Biodex Medical, Shirley, New York). A bubble goniometer (model 12-1056, Fabrication Enterprises, White Plains, NY)) was used for ROM.                                                                                   |                                                                                                                                                                                                                      |
| Skazalskiet al., 2021. | Norway. | Professional volleyball players | 81 Players various positions age= 23-26. | Players with baseline complaints (n = 22) Developed season complaints (n = 16) No complaint group (n = 43). | SAB thickness, and neovascularization assessments internal and external strength HHD; ergoFET500, Hoggan Scientific LLC, Salt Lake City, UT, USA). IR:ER strength ratio calculated. ROM with an inclinometer. Humeral torsion was measured for both arms using a diagnostic. | Greater IR strength and greater IR:ER strength ratios were observed in players with baseline complaints Having greater shoulder ER ROM increased a player's risk of developing complaints by 8% for every additional |

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|                           |                   |                                                         |                                                                                                                                     |                                                    | ultrasound device (MyLab25 Gold with LA523 transducer, Esaote, Genoa, Italy). A color Doppler was used to detect the presence or absence of vessels within the supraspinatus                           | degree. Players presenting with neovessels and/or increased SAB thickness; are 48% more likely to develop shoulder complaints. |
| Olivier et al., 2020.     | South Africa.     | Actively participating, provincial and club cricketers. | N=32. Male, provincial or premier league club cricketers, aged 18 years or older and exposed to a weekly cricket training workload. | Dominant arm versus non-dominant arm.              | ROM, TA ROM, GIRD and ERG) was measured using manual inclinometer (Kolber & Hanney 2012). Pectoralis minor muscle length was measured using rigid plastic right angled ruler (Lewis & Valentine 2007). | Asymmetries in ROM and pectoralis minor muscle.                                                                                |
| Peckitt and McCaig, 2019. | Loughborough, UK. | Professional county cricket players.                    | 18 male cricket players. Age=24.0 (4.3) years. Height=1.8 (0.1) m.                                                                  | One group, two testings, pre-season and in season. | Shoulder ROM elevation. Shoulder isometric Internal and external                                                                                                                                       | Those in the in-season 'playing, but with arm trouble'                                                                         |

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|                         |               |                     | Weight= 83.6 (7.7) kg.                                                                                                                      |                                | strength was collected using a Lafayette Manual Muscle Testing hand-held dynamometer Glenohumeral joint rotator total Arc ROM was collected using a Solatronic digital inclinometer. (model EN17).                       | group had greater ER non-dominant ROM compared to the 'no arm trouble group,' whilst players who developed in-season 'arm trouble' had a tendency towards lower Preseason ER:IR DOM strength ratios. |
| Finley and Ebaugh 2017. | Philadelphia. | Laboratory setting. | Wheelchair users. N=22 Participants. n=18= (M). n=4 (F). Age=41.68 (4.62) Height=177.50 (8.59) m. Weight: 80.06 (15.51). BMI= 25.12 (6.76). | One group. 18 men and 4 women. | PM length was defined as the distance between 2 bony landmarks: the coracoid process and inferior medial aspect of the fourth rib adjacent to the sternocostal junction using a caliper (Palpation Meter <sup>a</sup> ). | Association of reduced PMm extensibility with reduced shoulder girdle mobility, pain, and duration of wheelchair use in individuals with SCI.                                                        |

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| White et al., 2012. | Texas. | Local university sample of convenience | N= 58, n= 40 (F), n= 18 (M). Healthy adults with an average height (mean) (SD) of Age= 24.2 (5) years. Height=170 (9.3) cm). Weight=67 (12.6) kg. | Two groups. | Isometric Shoulder Internal and external rotation was measured using a tensiometer (Honeywell Sensotec Model GM, Columbus, OH, 500 lbs weight, accuracy of 0.02%Y1%). AHD measured using a MyLab. 25 grayscale ultrasound unit (Biosound Esaote, Indianapolis, IN). | In conclusion, submaximal isometric shoulder external rotation significantly decreased the AHD when compared with isometric shoulder internal rotation or no contraction at 45 degrees of shoulder abduction, whereas at 30 degrees of shoulder abduction, the AHD tended to decrease with isometric external rotation when compared with isometric internal rotation or no |
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|                       |          |                              |                                                                             |                                                 |                                             | contraction.                                                                            |
| Miranda et al., 2001. | Finland. | Forestry company in Finland. | N=5250.<br>Age between 35-55 years of age.<br>Years 1992, 1993, 1994, 1995. | One group.<br>Four consecutive years follow-up. | Shoulder pain modified Nordic questionnaire | Working with a hand above shoulder level increased the risk of developing shoulder pain |

*Table 5: Characteristics of Included Studies - Case Series Form*

| Study                | Country                               | Setting/context                                          | Participant characteristics                                                                                                                                                              | Groups    | Outcomes measured                                                                                                                                                           | Description of main results                                                |
|----------------------|---------------------------------------|----------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| Duzgun et al., 2017. | Hacettepe University, Ankara, Turkey. | University Sports Physiotherapy Unit for rehabilitation. | N= 155 Participants.<br>N= 104 ( ), n= 51 (M).<br>Age=49 (9.1), 50.4 (10.7), 58.2 (10.5), 37.4 (12.5) years.<br>BMI= (kg/m <sup>2</sup> ) 26.9 (4.4), 7.6 (5.5), 28.7 (4.4), 24.8 (4.4). | 4 groups. | Posterior capsule tightness was assessed in a side-lying position with a ruler from medial epicondyle to plinth position visual analogue scale was used for assessing pain. | Posterior capsule tightness was greatest in patients with frozen shoulder. |

60 *Table 6: Characteristics of Included Studies - Case Reports Form*

| Study           | Country | Setting/context      | Participant characteristics | Patients                  | Description of main results                                                                                          |
|-----------------|---------|----------------------|-----------------------------|---------------------------|----------------------------------------------------------------------------------------------------------------------|
| de Souza, 2019. | Brazil. | Swimming fraternity. | 19-year-old male.           | 19-year-old male swimmer. | Elongation of the posterior inferior capsule and the pectoralis minor muscle is essential to achieve muscle balance. |

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62 *Table 7: Characteristics of Included Studies - Prevalence Study Form*

| Study                  | Country | Year/timeframe for data collection | Participant characteristics                                                                                             | Conditions and measurement methods                                                                                                                                                                                                                                                                                    | Description of main results                                                                                                                                                                                    |
|------------------------|---------|------------------------------------|-------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Yamamoto et al., 2010. | Japan.  | Once off data collection.          | 683 people (total of 1,366 shoulders), including n=229 (M) and n= 454 (F) with a mean age of 57.9 years (range, 22-87.) | Impingement sign was determined according to the Neer's procedure. The active range of motion was measured in forward elevation at the scapula plane with the subject standing upright, and the loss of muscle strength was examined in abduction and external rotation with manual muscle testing on a scale of 0-5. | The current results showed that the subjects with rotator cuff tears were positive for impingement sign, showed lesser active forward elevation and weaker muscle strength in abduction and external rotation. |

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|  |  |  |  |  | <p>Ultrasonography was used to examine both shoulders to diagnose rotator cuff tears.</p> <p>according to the technique described by Middleton et al,<sup>11</sup> using. LOGIQ e (GE Health Care, USA) with linear-array probes at 12 MHz.</p> |  |
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64 *Table 8: Characteristics of Included Studies - Text and Opinion Study Form*

| Study                | Type of text       | Population represented | Topic of interest                                      | Setting/context/culture | Stated allegiance/position                                                                                                                                                             | Description of main argument(s)                                                                                                                                                               |
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| Saini et al., 2020 . | Literature review. | Tennis players.        | Scapular Dyskines is and the Kinetic Chain evaluation. | Tennis fraternity.      | This article aims to provide a comprehensive understanding of the evaluation, diagnosis, and management of scapular dyskinesis and its impact on the kinetic chain in tennis athletes. | Although shoulder pain in the overhead athletes is often multifactorial, early recognition and treatment of scapular dyskinesis generally carry a favourable prognosis and result in improved |

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|                       |                        |                                           |                                       |                                             |                                                                                                                                                                                                                                                                                                                                                                                                         | patient outcomes.                                                                                                                                                                                                                                                                                                                                      |
| Phadke et al., 2009 . | Literature review.     | Healthy subjects.                         | Scapula and rotator cuff musculature. | General population.                         | The rotator cuff plays a role not only in producing glenohumeral internal and external rotation, but more critically in stabilizing the humeral head on the glenoid. Thus, across studies, changes in the activity of the scapular muscles, especially trapezius and middle and lower serratus anterior, have been associated with various shoulder related pathologies including shoulder impingement. | Patients presenting either with excess scapular internal rotation or reduced scapular upward rotation may benefit from incorporation of lower trapezius exercises into their rehabilitation. As noted above, this reduced rotator cuff activation may contribute to further shoulder impingement with excess superior translation of the humeral head. |
| Bhatia et al.,        | Clinical case studies. | Three patients were competitive sportsmen | Pectoralis minor muscle.              | Overuse of the pectoralis minor muscle in a | This study describes the clinical features and                                                                                                                                                                                                                                                                                                                                                          | A simplified technique of                                                                                                                                                                                                                                                                                                                              |

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| 2007 .                   |                     | (rugby, swimming and body building) and four were non-competitive ones (recreational bodybuilding/fitness exercise). |                | young population.  | management of a previously undescribed condition of pectoralis minor insertional tendinopathy, secondary to bench press type of weightlifting.                                                                                   | ultrasound-guided injection of the pectoralis minor entheses is described. A new pain site-based classification of shoulder pathology in weightlifters is suggested.                                                     |
| Mora is and Cruz, 2016 . | Masterclass review. | Overhead athletes.                                                                                                   | PMm tightness. | Overhead athletes. | A rehabilitation approach focused on PMm stretching and simultaneous optimization of the kinematic chain of arm elevation is also discussed, hoping to improve the management of shoulder movement-related impairments and pain. | Given the possible interaction between PMm tightness and other biomechanical mechanisms and components of the upper body quadrant, PMm length should be assessed along with the examination of scapular mobility, muscle |

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|  |  |  |  |  |  | strength of its antagonist muscles, and posture and mobility of the head, cervical and thoracic spines. |
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67 *Table 9: Characteristics of Included Studies - Analytical Cross-Sectional Study Form*

| Study                  | Country | Setting/co<br>ntext                          | Participant<br>characteristic<br>s                                                                                                    | Groups                                                 | Outcomes<br>measured                                                                                                                                                                                                                                  | Main<br>descriptio<br>n of<br>results                                               |
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| Fifolato et al., 2021. | Brazil. | Workers from a tertiary university hospital. | N=27. N= 11 (M), n= 16 (W). Unilateral or bilateral shoulder pain present for 0-12 months. Both sexes between 25 and 60 years of age. | Two groups. Symptomatic side versus asymptomatic side. | Numerical pain rating scale (NPRS). Work ability index. Quick disabilities of the arm, shoulder and hand (Quick International). Physical activity questionnaire (IPAQ)-short version DASH-Br) Nordic musculoskeletal questionnaire Lateral preference | No significant difference in strength between the upper extremities was concluded . |

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|                         |        |                                              |                                                                                                                                    |                                           | inventory Isokinetic and isometric dynamometer testing Biodex System 4 Pro™ (Biodex Medical Systems, Inc., Shirley, NY, USA). Hand grip strength was assessed by a JAMAR™ isometric. Dynamometer .          |                                                                                                                                                                                                                                           |
| Maestroni et al., 2020. | Italy. | Sample of convenience from a private clinic. | n=67 Participants. N= 27 (F), n= 40 (M). Age (years). Mean (SD) (min, max) Age 49.6 y (11.6). Height (1.71 m (0.08). Weight 68 kg. | Two groups, symptomatic and asymptomatic. | Isometric strength of shoulder external rotator and internal rotator muscles; external: internal rotators measured with a HHD (JTECH Commander, PowerTrack, Utah), strength ratio calculated. NPR for pain, | There was no significant difference in internal rotator strength normalized to body weight between symptomatic and asymptomatic sides. Non-athletic people with rotator cuff related shoulder pain had external rotator strength deficits |

|                        |                            |                                                                                                |                                                                                                              |                                                                                                                                                                                                                                       |                                                                                                                                                                                  |                                                                                                                                                                                                                   |
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|                        |                            |                                                                                                |                                                                                                              |                                                                                                                                                                                                                                       |                                                                                                                                                                                  | without pain interference during strength testing.                                                                                                                                                                |
| Ishigaki et al., 2015. | Japan.                     | Divisional collegial baseball team.                                                            | N=39 (M) Participants. Age, 20.0 (1.36) years; height, 174.59 (5.47) cm; weight, 71.89 (7.61) kg.            | Thirty-nine collegiate baseball players, including 11 pitchers and 28 position players, painful shoulders. 16 Healthy collegiate baseball players (age, 19.4 $\pm$ 1.0 years; height, 169.0 $\pm$ 6.6 cm; weight, 62.3 $\pm$ 5.2 kg). | HAdd and IR ROM using a digital inclinometer (Survey Techno-Science, Nagoya, Japan). PCT measured by using a MyLab 25 ultrasound unit (Biosound Esaote). Indianapolis, IN, USA). | The results of the present study indicates that posterior shoulder capsule tightness only relates to IR ROM, and that restricted HAdd ROM might reflect tightness of other tissue, such as the posterior deltoid. |
| Jain et al., 2018.     | Nashville , Tennessee, USA | University controlled study at Vanderbilt University Medical Center, Nashville, Tennessee, USA | N= 301 Participants, n= 144 (F), n= 157 (M). 45 years of age and shoulder pain duration of at least 4 weeks. | Two groups, symptomatic versus asymptomatic.                                                                                                                                                                                          | External, internal rotation and abduction in neutral strength in neutral using a handheld dynamometer. Lift-off test,17 passive lift-off test,16 belly-press                     | Presented is a model that can accurately predict the diagnosis of a rotator cuff tear with satisfactory discrimination                                                                                            |

|                       |      |                                                                                |                                                                             |                                                 |                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                    |
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|                       |      |                                                                                |                                                                             |                                                 | test,16 belly-off sign,53 and bear hug test6 for the subscapularis; the external rotation. lag sign at 0_,23 external rotation lag sign at 90_,23 Jobe test. (empty can test),32,33 full can test,36 Neer sign,48 Hawkins-Kennedy sign,20 and drop arm test60 for the infraspinatus. and supraspinatus; and the horn blower sign58 for the teres minor/infraspinatus. | tion and calibration based on 4 variables: sex, lift-off test, Jobe test, and external rotation strength ratio affected versus non-affected arm.   |
| Reuther et al., 2018. | USA. | Professional baseball organization professional (both Major and Minor League). | N=30. Age: 22.5 (3.5) years. Weight: 96.1 (8.8) kg. Height: 190.8 (4.9 cm). | Dominant shoulder versus non-dominant shoulder. | HR-humeral retroversion PCT-posterior capsule thickness measured using a (SonoSite Titan Diagnostic Ultrasound Scanner; Fujifilm SonoSite, Bothell, WA, USA) using a                                                                                                                                                                                                  | When IR measurements were corrected by accounting for HR, GIRD was no longer present, indicating that soft-tissue tightness may not be responsible |

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|                      |      |                                       |                                                                                                                                                 |             | digital inclinometer (Saunders Group Inc, Chaska, MN)) (Glenohumeral IR and ER= TM                                                                                | e for the reduced IR observed. When ER measurements were corrected by accounting for HR, ERG became a deficit instead of a gain. These findings suggest a paradigm shift in the current assumptions regarding soft tissue changes and their relationship to total clinical ROM. |
| Reeser et al., 2020. | USA. | University-based clinic orthopaedics. | N=60 Participants. N= 23 (F), n= 37 (M). Age=34.0 (15.3) 38.4 (14.6) 29.9 (12.7) 39.2 (15.0) years. Height= 1.71 (0.10) 1.74 (0.10) 1.75 (0.09) | Two groups. | Scapula assistance test (SAT). Penn Shoulder Score for Pain. Active shoulder elevation in the scapular plane, defined as 40 degrees anterior to the frontal plane | The only significant between group difference based on the result of the SAT was in pectoralis minor muscle length.                                                                                                                                                             |

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|                      |          |                                              | <p>1.72 (0.10) m.</p> <p>Weight=</p> <p>77.2 (18.7)</p> <p>84.4 (17.1)</p> <p>79.6 (16.2)</p> <p>82.1 (18.8) kg.</p> <p>BMI, kg/m<sup>2</sup></p> <p>26.2 (5.5)</p> <p>27.9 (4.8)</p> <p>25.9 (4.5)</p> <p>27.7 (5.3).</p> |                                                                                                       | <p>using a goniometer.</p> <p>A HHD (microFET2; Hoggan Scientific, LLC, Salt Lake City, UT) was used for Ut, Mt, IT SA. Isometric assessment.</p> <p>PM muscle length was assessed using a tape measure.</p>                                                                                                             |                                                                                                                                                                                                       |
| Kolber et al., 2017. | Florida. | Weightlifting fraternity university setting. | <p>Fifty-five male adults, aged 21–56 (mean age 27) years, who participated in WT.</p>                                                                                                                                     | <p>Participants included 24 individuals presenting with SIS. 31 individuals who did not have SIS.</p> | <p>Strength Testing: Internal and external rotation strength; Abduction strength; Upper and lower trapezius strength. With a HHD (micro-FET2_ digital handheld dynamometer Hoggan Health Industries, Draper, UT). Active flexion, abduction, and external and internal rotation ranges of motion were tested using a</p> | <p>Upper trapezius muscle strength was significantly greater in the SIS group. AROM was significantly less in the WT group with SIS; for shoulder internal and external rotations group with SIS.</p> |

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|                         |                              |                                                                 |                                                                                                                                          |                                                        | translucent plastic 12-inch goniometer.                                                                                                                                                                                 |                                                                                                                                                                                             |
| Jeon et al., 2019.      | South Korea.                 | Office workers.                                                 | n=20 (F), (n=13) M.<br>Age= 23.4 (2.2) years.<br>Height = 176.7 (3.8) cm.<br>Weight= 69.1 (7.1) kg.<br>Hand dominance 15 Left; 18 Right. | Mouse work shoulder versus non-mouse worker shoulder.  | PM using a ruler (Johnson Level & Tool Mfg. Co, Inc., Mequon, WI), The examiner took pictures of each worker's head and shoulders. IR and ER (ROM) was measured using a universal goniometer (Jamar, Jackson, MI, USA). | The mouse shoulder showed more limited passive internal rotation (69.2% of the normal range) with pain (VAS 5.2) compared with the non-mouse shoulder (79.0% of normal range) without pain. |
| Ludewig and Cook, 2002. | Minnesota, Minneapolis, USA. | Construction workers in either sheet metal or carpentry trades. | N=52 (M).<br>Age=39 13.3 39.7 12.0<br>Height (m) 1.80 0.08 1.81 0.06<br>Weight (kg) 85.7 12.7 90.9 14.0                                  | Two groups. Asymptomatic versus Symptomatic shoulders. | Three-dimensional humeral translations were tracked with a 3-D motion sensor device (FASTRAK (Polhemus, Inc., Colchester, VT)) in symptomatic construction workers and an asymptomatic comparison                       | Persons with shoulder symptoms demonstrated small but significant changes in anterior-posterior translations of the humerus. These changes for the 90°–120° phase of                        |

|                      |                                |                                        |                                                                                                                                                                                               |                                                 |                                                                                                                                                                                                                                                                         |                                                                                                                    |
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|                      |                                |                                        |                                                                                                                                                                                               |                                                 | group while elevating the arm in the scapular plane under no-load, 2.3-kg, and 4.6-kg hand-load conditions. Between-group comparisons were made across 3 phases of motion (30°–60°, 60°–90°, and 90°–120°) and cross-body adduction and shoulder internal rotation ROM. | humeral elevation were moderately negatively associated with available cross-body adduction ROM.                   |
| Reeser et al., 2010. | Utah, Salt Lake City, UT, USA. | National champions hip sporting event. | A total of 422 athletes returned questionnaires, of whom 276 also underwent a structured physical examination. N=286 (M) n= 136 (W). Mean age of participants, years<br>21.5<br>20.9<br>21.3. | Three groups, questionnaire, females and males. | SICK scapula score-Scapular malposition, Inferior medial border prominence; Coracoid pain and malposition, and dyskinesia of scapular movement; GIRD; passive external glenohumeral rotation; isometric motor function of the shoulder external or internal rotators.   | A positive association between asymmetric coracoid tightness /pectoral shortening and shoulder pain was concluded. |

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|                              |                            |                                                           |                                                                                                                                                                                      |                                                                                                                                                                    | Functional neuromuscular trunk control; PM tightness; apprehension at the extreme of passive glenohumeral external rotation. A carpenter's level, positioned across the chest at the level of the coracoid, facilitated detection of any gross asymmetry for PM. |                                                                                                                            |
| Celeste and Overbeek , 2019. | University Medical Centre. | Outpatient clinic between January 2016 and November 2016. | SAPS (n= 40) Controls (n = 30) Age, years (mean, SD) 50 (6) 51 y (6) Female (n=23) (58) 17 (57) Right-side dominance (n= 35 (88) 25 (83). Dominant side affected (n=25) (63) 17 (57) | Forty patients with SAPS and 30 asymptomatic controls were compared. The SAPS and control groups were not different with respect to age, sex, and hand dominance . | Surface EMG (DelSys system Bagnoli-16, Boston, MA, USA) during rest and isometric abduction and adduction (using a one-dimensional force transducer).                                                                                                            | Patients with SAPS showed an altered adductor co-contraction pattern with reduced teres major activation during abduction. |
| Huang et al., 2016.          | Taipei, Taiwan             | An outpatient clinic of a                                 | N=51 Participants,                                                                                                                                                                   | One group; unilateral                                                                                                                                              | EMG activity of upper/middle/l                                                                                                                                                                                                                                   | Increased upper trapezius                                                                                                  |

|                      |                       |                      |                                                                                                                                                    |                                                                                                                  |                                                                                                                                                                                                                                                  |                                                                                                                |
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|                      |                       | university hospital. | n=40 (M), n=11 (F). Age=22.5 y (2.4) height=171.4 (8.0) cm; weight= 64.9 (10.5) kg.                                                                | shoulder pain around the glenohumeral joint while performing shoulder movement and had scapular dyskinesis.      | ower trapezius (UT/MT/LT) and serratus anterior (SA); horizontal adduction range of motion (ROM) and horizontal abduction ROM were measured, respectively, in supine position. Passive ROM of shoulder internal and external rotation in supine. | activity was the only factor associated with functional disability in patients with inferior angle prominence. |
| Finley et al., 2017. | Philadelphia, PA, USA | University campus.   | N=35, n=18 F), n= 17 (M). Between 18 and 35 years of age.                                                                                          | One group, free of current shoulder pain, and able to elevate their arms at least 130.                           | Pectoralis minor muscle length resting and activated.                                                                                                                                                                                            | A measuring method for obtaining PM muscle length extensibility.                                               |
| Ebaugh et al., 2018. | Philadelphia, PA, USA | University setting.  | N=30<br>One group: 6 males, 9 females.<br>Second group: 3 males, 12 females. Age (years) 26 (4.26). Height (m) 1.70 (0.08); 1.67 (0.09). Mass (kg) | Two groups;<br>One group; active pm length group-shelve reaching and scapular plane and elevation. Second group; | Length of pectoralis minor using a PALM (Performance Attainment Associates, St. Paul, MN)                                                                                                                                                        | No differences were found in active (typical or passive, short PMm elongation between groups.                  |

|                     |          |                                             |                                                                                                                                      |                                                  |                                                                                                                                                                                                                                          |                                                                                                                                                                                          |
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|                     |          |                                             | 66.2 (10.3)<br>66.1 (10.4).                                                                                                          | Passive resting pm length.                       |                                                                                                                                                                                                                                          |                                                                                                                                                                                          |
| Bond C. 2016.       | Wairaka. | Sample of convenience.                      | N=70. Healthy participants, between the age of 18 and 65 years with or without shoulder pain.                                        | Two groups; Healthy participants, Painful group. | PMLT and PMI. 4-Type System for monitoring of scapular dyskinesis.                                                                                                                                                                       | The findings of this study are indicative of a complex relationship between clinical measures of pectoralis minor muscle length, upward rotation, pain and observed scapular dyskinesis. |
| Gomes et al., 2020. | Brazil.  | Surfing fraternity, male amateurs' surfers. | N=21 (M), aged between 18 and 42 years, surfing for at least two years. Age 28(5) Height 1.76 (0.7). Hand dominance L =90.5. R =9.5. | One group.                                       | SD was evaluated through the methods slide lateral scapular test (SLST) (static evaluation) and filming (dynamic evaluation). The SLST consists of a bilateral measurement of the distance between scapula lower angle and corresponding | Although the athletes had SD and some of them had pain, this does not seem to have influenced their life quality and function.                                                           |

|                           |              |                                           |                                                                                                                                               |                                               |                                                                                                                                                                                      |                                                                                                                                                        |
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|                           |              |                                           |                                                                                                                                               |                                               | spinous process, with shoulder in three distinct positions: 0°, 45° and 90° abduction. Life quality was assessed through the Western Ontario Shoulder Instability Index (WOSI) NPRS. |                                                                                                                                                        |
| Yeşilyaprak et al., 2016. | Turkey       | University setting.                       | N=148 participants, n= 58 (F), n=90 (M). Age= 23.34 (3.94) years. Mean body mass index [BMI] 22.93 (3.10).                                    | Two groups; females and males.                | Scapular Dyskinesis Test (SDT). Measurement of pectoralis minor resting length (PMI) (standing) And length of trapezius sitting.                                                     | Having a shorter pectoralis minor and upper trapezius length substantially increased the likelihood of having visually observable scapular dyskinesis. |
| Lee et al., 2015.         | South Korea. | Outpatient setting sample of convenience. | N=34 participants, n=22 (F), n=12 (M). All subjects were at least 18 years of age and right side dominant. The mean and standard deviation of | Two groups, long PM group and short PM group. | Pectoralis minor muscle length test (pectoralis minor index). Serratus anterior muscle strength test. Posterior shoulder tightness test                                              | All predictor variables, including posterior shoulder tightness, should be considered while assessing, managing,                                       |

|                              |         |                                           |                                                                                                                                                                                                                                                                                                              |                                                                                          |                                                                                                                                                                                          |                                                                                                                                                                                                              |
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|                              |         |                                           | age, weight, and height were Age; 33.78 (11.15) years; weight; 57.81 (9.10) kg, and Height; 1.64 (0.07) m.                                                                                                                                                                                                   |                                                                                          | (the amount of glenohumeral internal rotation). Posterior shoulder tightness test (the amount of glenohumeral horizontal adduction.) Thoracic spine angle measurement in sagittal plane. | and preventing forward scapular posture.                                                                                                                                                                     |
| Lubiatowski P, et al., 2018. | Poland. | Male elite professional handball players. | Eighty-seven elite professional male handball players Forty-one healthy non-athlete volunteers were included in the control group based on the following inclusion criteria: age 20–30; no history of shoulder injury, surgery, pain and/or dysfunction; and no history of professional sport participation. | Two groups. Forty-one healthy non-athlete volunteers were included in the control group. | Measurement of shoulder range of internal rotation (IR) and external rotation (ER) with a goniometer, visual analogue scale, Ultrasound scan.                                            | Greater glenohumeral rotational deficits in throwing shoulders of handball players correlate with shoulder pain and internal impingement, while increased external rotation with partial rotator cuff tears. |

|                                |        |                                   |                                                                                                                                                                                                     |                                                                   |                                                                                                                                                      |                                                                                                                                   |
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|                                |        |                                   | The average age in the players group was 25 years (SD 4.7, range 18–38), height was 188 cm (SD 6, range 175–202) and weight was 92 kg (SD 11, range 64–125 kg).                                     |                                                                   |                                                                                                                                                      |                                                                                                                                   |
| Benitez-Martinez et al., 2017. | Spain. | Overhead athletes.                | Male n=81<br>age: 26.11 (8.4) y,<br>height: 180 (6) cm, BMI: 24.6 (2.2) kg.                                                                                                                         | Two groups; pain full group and non-painful group.                | Cross-sectional area (CSA), AHD, VAS using a portable Logic-e Ultrasound Scanner (GE HealthCare, Wauwatosa, WI, USA). Shoulder Rating Questionnaire. | Significant atrophy and reduction in the CSA of the supraspinatus muscle of the painful shoulder, compared with healthy controls. |
| Moreno-Perez et al., 2015.     | Spain. | Professional male tennis players. | 47 Male participants.<br>Age (years)<br>23.2 ± 4.9<br>22.2 ± 4.3<br>25.6 ± 3.0<br>3.624 0.063<br>Height (cm)<br>183.6 ± 5.0<br>184.1 ± 5.8<br>182.7 ± 3.6<br>0.886 0.352<br>Mass (kg)<br>77.5 ± 6.5 | Two groups. 19 in the Painful group, 28 in the non-painful group. | IR, TROM, ER. Photographs taken and digitally analysed.                                                                                              | In professional tennis players, limited IR ROM rather than a GIRD, seems to be associated with shoulder pain history.             |

|                    |            |                                                                    |                                                                                                                                                                                                                                                   |                                                                                        |                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                 |
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|                    |            |                                                                    | 77.60 ± 7.6<br>77.5 ± 4.8                                                                                                                                                                                                                         |                                                                                        |                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                 |
| Wong 2020.         | Hong Kong. | University laboratory.                                             | 56 participants. Age, y 26.0 (1.8); 23.9 (4.5); 26.7 (4.9). Gender (M: F) 15:16; 11:3; 6:5. Height, m 1.7 (0.1); 1.7(0.1); 1.7(0.1). Weight, kg 58.9 (8.2); 68.9 (6.5); 66.5 (12.6).                                                              | Two groups; twenty-five elite softball players and 31 asymptomatic sedentary controls. | Isokinetic concentric IR and ER peak torque and fatigue ratio were measured at 60°/s and at 180°/s, respectively; and ultrasound measurement of the SAS was measured during 0° and 60° of shoulder abduction.                                                                 | Decreased strength ratio and fatigue ratio of ER/IR were related to reduction of the SAS.                                                                                                       |
| Rosa et al., 2019. | Brazil     | University setting, orthopaedic clinics, and surrounding community | N= 50, n= 26 (F), n= 24 (M). Age, y 27.4 ± 6.6 29.0 ± 8.0 32.2 ± 12.3 33.5 ± 10.1 2.48 (3) .06 Height, m 1.69 ± 0.08 1.70 ± 0.10 1.68 ± 0.12 1.68 ± 0.10 0.19 (3) .89 Weight, kg 67.98 ± 11.73 70.04 ± 12.28 71.46 ± 15.61 69.88 ± 10.77 0.12 (3) | Control group (n = 28) PCT group (n = 27) SIS group (n = 25), SIS + PCT group (n = 25  | Scapular kinematics and humeral translations were quantified with an electromagnetic motion capture system. Shoulder internal rotation and external rotation ROM, external rotation strength, and pain and Shoulder Pain and Disabilities Index score. PCT was estimated with | Decreased ROM and lower pain thresholds were found in individuals with both impingement symptoms and PCT. However, the combination of factors did not influence scapular and humeral kinematics |

|                           |               |                                |                                                                                                 |                                     |                                                                                                                                                                                                                         |                                                                                                                                |
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|                           |               |                                |                                                                                                 |                                     | the Low Flexion Test (LFT). ROM measured by a digital inclinometer (Acumar, Lafayette Instrument Co, Lafayette, IN, USA).                                                                                               |                                                                                                                                |
| Turgut and Baltaci, 2018. | Turkey.       | Sample of convenience.         | N=58.<br>29 Symptomatic individuals.<br>29 Asymptomatic individuals.                            | Two groups.                         | Relationship between pectoralis minor (PMLT) posterior capsule flexibility (inside lying) deficits and scapular asymmetry in the resting position and during arm elevation in asymptomatic and symptomatic individuals. | Increased deficit in the pectoralis minor and posterior capsule flexibility were associated with increased scapular asymmetry. |
| Oyewole, 2019             | South Africa. | Wheelchair basketball players. | Participants who were 18 and above. Two male clubs and one female club. 21 males and 4 females. | Two groups. 21 Males and 4 Females. | Wheelchair User's Shoulder Pain Index Questionnaire for extrinsic risk factors. The Apprehension test and relocation test. Sulcus sign test: Load and shift test: External                                              | The association between participants who reported shoulder pain prior to wheelchair use and left external range of motion of   |

|                                         |        |                              |                                                                                                                                                                                                                                                                                                                |                                                                 |                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                       |
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|                                         |        |                              |                                                                                                                                                                                                                                                                                                                |                                                                 | rotation<br>Internal<br>rotation ROM.<br>(12-inch<br>plastic<br>baseline<br>goniometer<br>model 12-<br>1000) White<br>Plains, New<br>York).<br>Association<br>between<br>shoulder pain<br>history and<br>range of<br>motion. | the<br>shoulder<br>was<br>significant<br>.                                                                                                                                                                                                                                                                            |
| Navarro-<br>Ledesmae<br>t al.,<br>2019. | Spain. | Primary-<br>care<br>centres. | 108<br>participants<br>aged<br>between 18<br>and 45 years<br>of age.<br>Age =46<br>(43.67-<br>49.11) years.<br>N=54 (F);<br>n=54 (M).<br>Height (cm)<br>164.42<br>(160.20-<br>168.65).<br>One group<br>(54) with<br>unilateral<br>shoulder pain<br>and the other<br>group (54)<br>without<br>shoulder<br>pain. | Two<br>groups.<br>Symptoma-<br>tic versus<br>asymptoma-<br>tic. | Scapula<br>upward<br>rotation (SUR)<br>test. Pectoralis<br>minor length<br>(PMLT).<br>Shoulder pain<br>and disability<br>index<br>(SPADI).                                                                                   | PML is<br>poorly<br>associated<br>with<br>AHD, as<br>well as<br>with<br>shoulder<br>pain and<br>mobility,<br>in people<br>with<br>chronic<br>shoulder<br>pain. SUR<br>was<br>greater in<br>patients<br>with<br>chronic<br>SAPS<br>compared<br>with<br>controls at<br>different<br>angles of<br>shoulder<br>elevation. |

|                              |               |                                                                        |                                                                                                                  |                                                |                                                                                                                                                 |                                                                                                                                                                                                   |
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| Muhle et al., 2020.          | South-Africa. | University setting.                                                    | N=144, between ages 18 and 24 from the Faculty of Health Sciences.                                               | Two groups.                                    | PML -index                                                                                                                                      | The significant differences between the active and posterior tilt positions suggested that optimal muscle length of PM was affected by the inner range strength of the lower fibres of Trapezius. |
| Sarioglu and Pekyavas, 2021. | Turkey.       | University Hospital's Physical Medicine and Rehabilitation Department. | 30 Asymptomatic participants and 30 symptomatic participants aged 20 to 40.                                      | Two groups. Asymptomatic versus symptomatic.   | Trunk Flexibility-modified Schober test TLF Flexibility.                                                                                        | For the participants we studied, the flexibility of the TLF was not associated with SAIS.                                                                                                         |
| Struyf et al., 2014.         | Belgium       | Outpatient based private setting.                                      | N= 50. Age (y) Mean (SD) 50.8 (16.3) 20.8 (1.5) Gender Male 8 (32%) 16 (64%) Female 17 (68%) 9 (36%) Height (cm) | 25 patients with SIS and 25 pain-free controls | Intra-rater reliability and reliability of PMI test. The instruction was to palpate two anatomical reference points which in line represent the | Concluded Results: the PMI measurement has good to excellent intra-rater reliability and poor to moderate                                                                                         |

|                              |                       |                        |                                                                                                                                    |                                                                                                                     |                                                                                                                                                                                                        |                                                                                                                                                                                                                                                  |
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|                              |                       |                        | Mean (SD)<br>169.2 (9.9)<br>175.7 (9.8)<br>Body weight<br>Mean (SD)<br>74.5 (15.5)<br>72.6 (13.7)                                  |                                                                                                                     | PMLI muscle:<br>(1) the<br>inferomedial<br>aspect of the<br>coracoid<br>process and<br>(2) the caudal<br>edge of the<br>fourth rib at<br>the sternum.                                                  | inter-rater<br>reliability.                                                                                                                                                                                                                      |
| Sebastian<br>et<br>al.,2017. | Livonia,<br>USA       | Outpatient<br>clinic.  | 30 patients<br>with<br>shoulder<br>pain.                                                                                           | Two<br>groups:<br>uni- lateral<br>shoulder<br>pain<br>and<br>uni-lateral<br>no pain<br>shoulder.                    | PML in<br>supine.                                                                                                                                                                                      | The<br>Scapula<br>backward<br>tipping<br>test<br>(SBTT)<br>may be<br>incorporat<br>ed as a<br>simple yet<br>effective<br>test to<br>determine<br>the<br>presence<br>of PM<br>tightness<br>and<br>subsequen<br>tly scapula<br>forward<br>tipping. |
| Park et<br>al., 2021.        | Republic<br>of Korea. | University<br>setting. | 58 Males,<br>age, height,<br>and body<br>weight were<br>21 (1.1)<br>years, 179<br>(5.4) cm, and<br>83.9 (9.7 kg),<br>respectively. | 29 college<br>baseball<br>players<br>throwing<br>arm,<br>29 college<br>baseball<br>players non<br>-throwing<br>arm. | External<br>rotation (ER)<br>and internal<br>rotation (IR)<br>of the shoulder<br>using a digital<br>inclinometer<br>and PCT<br>thickness<br>using an<br>ultrasound<br>machine<br>(Aplio i700<br>(Canon | SW (shear<br>wave<br>elastograp<br>hy<br>velocity)<br>is closely<br>related to<br>posterior<br>shoulder<br>capsular<br>tightness.                                                                                                                |

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|                           |                                   |                                                   |                                                                                                                                                                                   |                                                            | Medical Systems Co., Otawara, Japan).                                                                                                            |                                                                                                                                                                    |
| Harrington et al., 2014.  | North Florida, Jacksonville, USA. | NCAA Division I swimmers in the state of Florida. | Female, (n = 37).<br>age = 19.5 (1.19) y,<br>height = 170 (7) cm,<br>weight = 64.7 (6.8) kg,<br>body-mass index = 22.5 (2.3) kg/m <sup>2</sup> .                                  | Dominant arm of swimmers and non-dominant arm of swimmers. | PMI (PALM's (Performance Attainment Assoc, St Paul, MN) shoulder pain and disability in dominant arm and non-dominant arm of swimmers were used. | Significant difference in dominant arm resting and stretched pectoralis minor muscle length between female swimmers with and without shoulder pain and disability. |
| Kara and Duzgun I. 2019.  | Turkey.                           | Laboratory controlled study.                      | Twenty-two participants (11 females, 11 males) with a diagnosis of SAIS and 22 healthy controls (11 females and 11 males) matched with age and gender participated in this study. | Two groups SAIS versus healthy controls.                   | EMG activity of UT, MT, and LT were measured with electromyographic studies (Noraxon Telemyo DTS System, Scottsdale, USA).                       | The UT/LT ratio during scapular retraction with external rotation at 0 degrees was significantly lower than all other exercises.                                   |
| Borstad and Ludewig 2002. | Minneapolis, USA.                 | Construction workers in the sheet metal and       | Healthy and symptomatic, n=52.<br>Mean SD<br>Age (years)                                                                                                                          | Healthy group versus symptomatic group.                    | Scapular upward rotation, scapular internal                                                                                                      | Averaged across phases, the                                                                                                                                        |

|                       |      |                                                                                                                             |                                                                                                                                                 |                                                                                                                       |                                                                                                                                                                                                                |                                                                                                                                                                                                                          |
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|                       |      | carpentry trades.                                                                                                           | 39.9 (13.3)<br>39.7 1(2.0)<br>Height (m)<br>1.80 (0.08)<br>1.81 (0.06)<br>1.67–1.93<br>Weight (kg)<br>85.7 (12.7)<br>90.9 (14.0)                |                                                                                                                       | rotation and scapular tipping FASTRAK electromagnetic motion capture system (Polhemus Inc., Colchester, VT, USA) was used to track 3-D position and orientation of each subject. thorax, scapula, and humerus. | symptomatic group. demonstrated significant reductions in upward rotation at lower humeral elevation angles, and significant increases in anterior. tipping at higher elevation angles as compared to the healthy group. |
| Riemann et al., 2010. | USA. | Participants at a local university and local area fitness centers in Armstrong Atlantic State University, Savannah, GA, USA | Variable<br>Men (n = 90) Women (n = 91)<br>Age, years 23.3<br>4.8 23.4 4.1<br>Height, m 1.79 .08<br>1.64 .08<br>Mass, kg 81.4 14.0<br>64.7 16.9 | 181 healthy volunteers' sample of convenience Men (n = 90) 181 healthy volunteers' sample of convenience Men (n = 91) | Shoulder internal and external rotator cuff strength were measured with a hand-held Baseline 250 hydraulic push-pull dynamometer (Baseline Corporation, Irvington, NY).                                        | Because there are no differences between the seated at neutral and 30°-30°-30° positions and the advantages it offers, we recommend the 30°-30°-30° position for testing and the initiation                              |

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|                      |                                         |                                                         |                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                           | of<br>rehabilitat<br>ion.                                                                                                                                                                                                                                              |
| Rosa et al.<br>2019. | Brazil                                  | local<br>university<br>setting and<br>communit<br>y     | Asymptomat<br>ic group (n =<br>25)<br>Symptomatic<br>group (n =<br>25) Gender<br>13 women;<br>12 men 13<br>women; 12<br>men Age<br>(years) 21.60<br>± 2.50 22.48<br>± 2.70<br>Height (m)<br>1.70 ± 0.08<br>1.72 ± 0.09<br>Weight (kg)<br>67.80 ±<br>12.18 69.66<br>± 15.36 | 18 and 30<br>years of<br>age<br>convenienc<br>e sample of<br>25<br>individuals<br>asymptoma<br>tic group25<br>symptomat<br>ic group.                                                                              | PMI was<br>measured with<br>a tape seated<br>and in supine<br>position.<br>GHJ ER ROM<br>measured with<br>a digital<br>inclinometer<br>(Acumar™,<br>Lafayette<br>Instrument<br>Company,<br>Lafayette,<br>Indiana).                                        | A<br>significant<br>negative<br>correlatio<br>n between<br>PMI<br>resting<br>length.<br>and GHJ<br>ER ROM<br>in the<br>seated<br>position<br>was noted<br>in the<br>asymptom<br>atic group<br>(r = -0.41;<br>p = 0.04),<br>but not in<br>the<br>symptoma<br>tic group. |
| Laudner,<br>2004.    | Universit<br>y of<br>Pittsburg<br>h USA | Controlled<br>laboratory<br>setting at a<br>university. | N=22.<br>Impingement<br>Group n=11.<br>Healthy<br>n=11. Group<br>Mean ±SD<br>Mean ±SD<br>Age (yrs)<br>22.09 3.45<br>21.18 1.72<br>Height (m)<br>1.84 0.07<br>1.83 0.06<br>Mass (kg)<br>90.99 14.62<br>89.86 12.99.                                                         | Impingeme<br>nt Group<br>The<br>experiment<br>al subjects<br>consisted<br>of 6<br>pitchers<br>and 5<br>position<br>players,<br>Healthy<br>Group the<br>control<br>group<br>consisted<br>of 4<br>pitchers<br>and 7 | Passive range<br>of motion<br>internal and<br>external rom<br>measured with<br>a goniometer,<br>posterior<br>capsule<br>tightness<br>(Tyler et<br>al,2002.)<br><br>Biodex<br>System 3<br>isokinetic<br>Device used<br>for isokinetic<br>ER, Ir and<br>ABD | Significan<br>tly<br>decreased<br>internal<br>rotation<br>and<br>increased<br>posterior<br>capsule<br>tightness<br>among the<br>impingem<br>ent group<br>compared<br>to the<br>healthy<br>group.                                                                       |

|                     |         |                                                                 |                                                                                                                                                                                                                                                                                                                                                             |                                                                                       |                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                               |
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|                     |         |                                                                 |                                                                                                                                                                                                                                                                                                                                                             | position<br>players                                                                   |                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                               |
| Cools et al., 2016. | Belgium | Different sports disciplines : tennis, volleyball and handball. | <p>Males (n = 101) Females (n = 100)</p> <p>Age (years)<br/> <math>27.3 \pm 8.3</math><br/> <math>27.8 \pm 8.5</math></p> <p>Height (m)*<br/> <math>1.83 \pm 0.06</math><br/> <math>1.69 \pm 0.07</math></p> <p>Mass (kg)*<br/> <math>80.4 \pm 11.2</math><br/> <math>65.8 \pm 9.3</math></p> <p>BMI♦ <math>24 \pm 2.8</math> <math>22.9 \pm 2.7</math></p> | Two groups. 101 Male healthy overhead athletes, 100 female healthy overhead athletes. | <p>RC strength isometric ER and IR strength measured with a HHD (</p> <p>MicroFET 2, Hoggan Health Industries Inc., Biometrics, The Netherlands).</p> | <p>ER, measured with a HHD, should be higher than the isometric IR strength, in both positions. In addition, side and gender differences were apparent, with lower ER values for the male athletes on their dominant side. These results might reflect an increased risk of injury in these subjects, given the fact that weakness in the external rotator was establishe</p> |

|                                     |           |                                |                                                                             |                                                                                     |                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                         |
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|                                     |           |                                |                                                                             |                                                                                     |                                                                                                                                                                                                                                                 | d to be a risk factor for throwing related shoulder pain.                                                                                                                                                               |
| DOS SANTOS De Andrade et al., 2010. | Brazil    | Brazil National Handball Team. | N= 27 (F). Age 23.0+3.4 years, weight 71.0+10.6 kg, and height 1.73+0.07 m. | Asymptomatic players.                                                               | Strength of internal and external rotators was tested through 120 degrees of range of motion between 60 degrees of internal and external rotation measured with a Biodex. System 3 dynamometer (Biodex Medical Systems Inc., Shirley, NY, USA.) | Our results suggest that concentric strength exercises be used for internal and external rotators on the nondominant side, and functional exercise that improves eccentric rotation strength for prevention programmes. |
| Kim et al., 2009.                   | Missouri. | Sample of convenience          | Men and Women = 237. 144 men and ninety-three women.                        | Four groups. Subjects who were forty to forty-nine years subjects who were fifty to | Ultrasonography was performed. On the LHB, subscapularis, supraspinatus and infraspinatus (scanner (Zonare                                                                                                                                      | When there is a substantial decrease in abduction strength in relation to external rotation                                                                                                                             |

|                        |                    |                                |                                                            |                                                                                                   |                                                                                                                                                                                                                                                                                                       |                                                                                                     |
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|                        |                    |                                |                                                            | fifty-nine years subjects who were sixty to sixty-nine years subjects who were seventy years old. | Medical Systems, Mountain View, California) and a variable high-frequency linear array transducer (5 to 10MHz). Measurements for abduction in the scapular plane and external rotation with an Isobex dynamometer (Cursor AG, Bern, Switzerland) was used to measure the isometric shoulder strength. | strength, the presence of an asymptomatic full thickness tear should be suspected in that shoulder. |
| Mankad and Jagad 2016. | Rajkot.            | Physiotherapy college, RAJKOT. | N=200 participants, n= 176 (F); n=24 (M). Age 18-25 years. | One group. Healthy collegiate individuals .                                                       | PMI with a protractor.                                                                                                                                                                                                                                                                                | There is prevalence of tightness of pectoralis minor in healthy collegiate individuals.             |
| Lee et al., 2020.      | Republic of Korea. | University setting.            | Participants: n= 22 (F); n=12 (M). Short PM (n=18) Long    | Two groups. The inclusion criterion                                                               | Scapula reposition test (SRT), VAS, isometric shoulder                                                                                                                                                                                                                                                | In the short pectoralis minor group,                                                                |

|                  |                    |                                                                                |                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                               |                                                                                                                          |                                                                                               |
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|                  |                    |                                                                                | PM (n=16)<br>Gender Male<br>6 6 Female<br>12 10<br>Age (years)<br>23.77 (4.50);<br>21.93 (3.53)<br>BMI (kg/m2)<br>21.85 (2.52);<br>20.73 (1.56). | was reported pain intensity of at least 1.4 cm on a visual analogue scale (VAS) during one of three impingement tests (Neer, Hawkins-Kennedy, and the empty can test), which is the minimal clinically importance difference reported in shoulder pain participant s assigned to the long PM group versus the short PM group. | elevation strength with a hand-held dynamometer (CommanderT M Muscle Tester; JTECH Medical, Midvale, UT, USA). PMI test. | shoulder elevation strength was significantly improved by scapular reposition test.           |
| Forthomme. 2018. | France and Belgium | Male team handball senior divisions (the highest level) in France and Belgium. | 108 male high level handball players (age ¼ 24 6 4 years, height ¼ 189 6 6 cm, mass ¼ 87 6 11 kg)                                                | Two groups; dominant arm and non-dominant arm.                                                                                                                                                                                                                                                                                | Internal rotators, Nm/kg External rotators, Nm/kg Ratio of external rotators: internal rotators Mixed ratio (external    | For traumatic injuries, the concentric maximal strength developed by the internal rotators at |

|                         |         |                                                         |                                                                                                            |                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                   |
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|                         |         |                                                         |                                                                                                            |                                                                                                                                                                     | rotators in the eccentric mode at 60°/s to internal rotators in the concentric mode measured using an isokinetic dynamometer (model Cybex HUMAC NORM; Computer Sports Medicine, Inc, Stoughton, MA).                                                                                                          | high speed (2408/s) in the dominant shoulder was a protective factor against the risk of further injury                                                                                                                           |
| Nordqvist et al., 2021. | Sweden. | Swedish primary care unit in the county of Östergötland | Participants included in analyses (n = 164) n= 64 (F); N= 100 (M). Age in years: mean (SD) 52 (9); 52 (9). | Participants included in analyses (n = 164) Participant s in RCT (n = 123) Participant s in implementation study (n = 132) Participant s with missing data (n = 91) | AROM, was measured with a handheld goniometer, included examination of flexion, abduction and external rotation, and was performed with the patient standing f resisted isometric manual resistance by the PT, testing in two different positions; approximately 30 degrees of abduction, as well as external | Rotator cuff dysfunction, defined as pain during resisted isometric muscle-testing in one direction or more, is very frequent while limitation in AROM and scapular dyskinesia are more inconsistent findings. All three componen |

|                     |              |                                 |                                                                                                                                                                    |                                      |                                                                                                                                                                                       |                                                                                                                                                                                                                 |
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|                     |              |                                 |                                                                                                                                                                    |                                      | rotation and internal rotation with the elbow flexed to 90 degrees and the upper arm alongside the thorax scapular kinematics, was assessed according to the classification of Kibler | ts are unique and not significantly correlated with each other which highlights their respective relevance.                                                                                                     |
| Olivier et al.,2018 | South Africa | Provincial and club cricketers. | 32 Male, provincial or premier league club cricketers, aged 18 years or older and exposed to a weekly cricket training workload, a mean age of 23.56 years (4.27). | Two groups injured versus uninjured. | ER, IR, TROM PML. ER and IR measured with a plastic handheld goniometer.                                                                                                              | Decreased combined. elevation, increased shoulder internal rotation ROM on the nondominant side and increased GIRD were associated with in - season. non-contact lower quarter injuries in domestic cricketers, |