

Neuromuscular Compensation Strategies in Patients with Supraspinatus Pathology: A Systematic Review

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Introduction and Objective

- Neuromuscular compensation within the the surrounding shoulder musculature may play a key role in preserving function despite structural failure of the supraspinatus in asymptomatic patients with shoulder pathology before pain is felt.
- Most painless rotator cuff tears eventually become painful given time
- Understanding compensatory patterns may improve early detection of dysfunction and treatment strategies
- Individual studies have explored this phenomenon, but no complete meta- analysis or systemic review has been performed to assess for trends of neuromuscular compensation
- The purpose of the study was to analyze all available studies evaluating neuromuscular activity in the setting of supraspinatus pathology
- The authors believed that there will be altered muscle activation in the surrounding musculature in supraspinatus pathology when compared to controls independent of pain reported

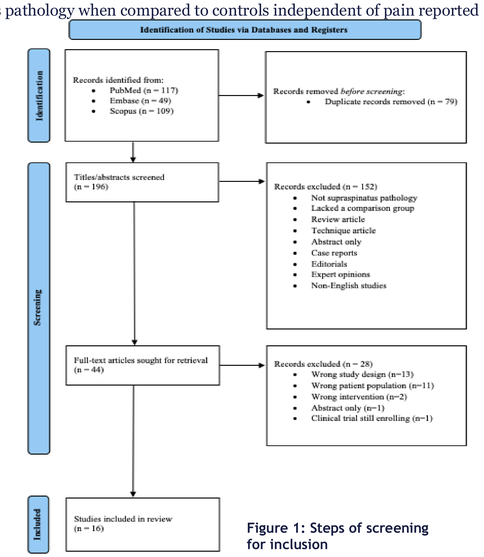


Figure 1: Steps of screening for inclusion

Methods

- A systematic review was performed using PubMed, Embase, and the Cochrane Central Register of Controlled Trials (Central) in May 2025 with all studies published to that point
- The population was any patient with supraspinatus pathology regardless of pain reported
- Inclusion criteria contained original studies (level of evidence 1-4) that examined neuromuscular activity of the shoulder and surrounding muscles in patients or cadaveric models in the setting of supraspinatus pathology which included a control group in the form of contralateral normal shoulder, same shoulder before pathology, or control group
- Exclusion criteria was concomitant pathology of other rotator cuff/shoulder muscles and no comparison group

Methods *(continued)*

- Abstracts were reviewed by MT and NU independently to assess for inclusion and exclusion with disputes being settled by another independent reviewer MM
- Data on study characteristics, pathology type, EMG or kinematic measures, and biomechanical variables were extracted (Figure 1)
- Due to data heterogeneity, a meta-analysis was not feasible
- A narrative synthesis of the data was performed from the resulting data

Results

- 16 articles met the criteria for inclusion

Scapular

- Five studies looked at scapular muscle behavior in SIS patients
- Three of these studies looked at muscle activation during dynamic arm elevation within the scapular plane in either unloaded or lightly loaded conditions. All three found no significant differences in EMG amplitude of isolated serratus anterior or trapezius when compared to controls (Figure 2).
- Four of these five studies looked at timing metrics, external load, and intermuscular coordination with all four finding significantly different neuromuscular control strategies at the scapula in the SIS groups when compared to controls.

Rotator Cuff and Deltoid

- Six of the studies examined rotator cuff, deltoid, and secondary shoulder muscle activation during functional or elevation tasks of the shoulder.
- Four of these studies looked at muscle activation during dynamic elevation. In low load conditions, three of the four found significant reduced activation of the deltoid or infraspinatus while none found significant changes in supraspinatus activation. The pattern displayed shows selective unloading of certain stabilizers rather than just complete rotator cuff inhibition in shoulder pathology.
- Five of the studies reported increases in muscle activation involving the biceps brachii, pectoralis major, latissimus dorsi, or posterior deltoid. This pattern shows compensatory muscle recruitment to aid in the performance of elevation tasks and shoulder stabilization.

Muscle	Weighted mean (%MVIC) control group	Weighted mean (%MVIC) pathology group	Mean difference
Upper Trapezius	18	18.07	0.07
Middle Trapezius	11.3	11.97	0.67
Lower Trapezius	16.97	13.1	3.87
Serratus Anterior	27.9	24.23	3.67

Figure 1: Pooled EMG amplitude means and differences between healthy control and pathology groups in scaption

Table 1. Summary of Studies Included for Review

First Author (Year)	Level of Evidence	Setting	Cuff Pathology	Sample Size (M:F)	Mean Age (years) (Experimental, Control)
Ballantyne (1993)	4	Clinical	Impingement with tendinitis of rotator cuff	40 (23:17)	28 ± 6 (18-40)
Berth (2009)	4	Clinical	Full-thickness RCT	23 (20:3)	65 ± 5 (55-71), 27 ± 8 (20-48)
Castelein (2016)	4	Clinical	Impingement syndrome	37 (0:37)	30 ±10, 29 ± 12
De Morais Faria (2008)	4	Clinical	Impingement syndrome	20 (8:12)	29 ± 6, 29 ± 5
De Witte (2014)	4	Clinical	Full-thickness RCT	58 (27:31)	Cuff tear: 65 ± 10, SIS: 50 ± 2, Control: 50 ± 7
Genter (2024)	4	Cadaveric	Full-thickness RCT	8 (6:2)	48.2 ± 8.9*
Hoshikawa (2024)	4	Cadaveric	Full-thickness RCT	8 (6:2)	57
Larsen (2013)	4	Clinical	Impingement syndrome	31 (15:16)	41 ± 14, 39 ± 12
Lopez-Pascual (2017)	4	Clinical	Full-thickness RCT	28	47 ± 11, 57 ± 7
Ludewig (2000)	4	Clinical	Impingement syndrome	52 (52:0)	40 ± 12 (25-68), 40 ± 13 (20-71)
Michaud (1987)	4	Clinical	Supraspinatus tendinitis	20 (12:8)	29 ± 7, 30 ± 4
Phadke (2013)	4	Clinical	Impingement syndrome	49 (26:23)	35 ± 13, 32 ± 10
Roe (2000)	4	Clinical	Rotator cuff tendinosis	19 (11:8)	39 (25-51), 37 (27-62)
Skolimowski (2009)	4	Clinical	Impingement syndrome	58 (19:39)	56 ± 16.3*
Veen (2021)	4	Clinical	Small/moderate supraspinatus tears (Patte stages 1-2)	23 (12:11)	65 ± 3 (52-83), 61 ± 2 (50-72)
Yu (2024)	4	Clinical	Subacromial pain	38 (19:19)	22 ± 3, 24 ± 5

RCT = Rotator cuff tear, SIS = Subacromial impingement syndrome, * = value was approximated using median and interquartile range.

Conclusions

- Supraspinatus pathology is associated with altered neuromuscular activation and disrupted force mechanics at the shoulder based on the data examined
- These changes could explain why many rotator cuff tears remain asymptomatic and pain free
- Recognizing these neuromuscular compensation patterns may greatly improve the diagnostic ability of early progression rotator cuff tears that are asymptomatic for earlier intervention
- These compensation patterns could also lead to better clinical assessment, rehabilitation methods, and lead future research aimed at muscle-based interventions for rotator cuff pathology

References

1. Veen EJD, Koorevaar CT, Verdonschot KHM, et al. Compensatory movement patterns are based on abnormal activity of the biceps brachii and posterior deltoid muscles in patients with symptomatic rotator cuff tears. *Clin Orthop Relat Res*. 2021;479(2):378-388.
2. Origin MRI & Diagnostics. *Electromyography (EMG)*. Origin MRI & Diagnostics.
3. For full list, ask authors for reference sheet