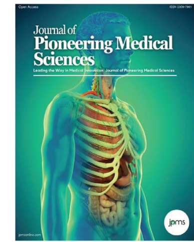
Journal of Pioneering Medical Sciences
Received: January 10, 2026 | Accepted: April 08, 2026 | Published: April 15, 2026
Volume 15, Issue S01, Pages 221-225

DOI https://doi.org/10.47310/jpms202515S0141



Infraspinatus Dysfunction in Cervical Radiculopathy: A Cross-Sectional Study

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Abstract **Background:** Cervical radiculopathy is a common cervical spine disorder resulting from nerve root compression, leading to radiating upper limb pain, weakness and sensory disturbances. The infraspinatus muscle, a key component of the rotator cuff innervated primarily by the C5–C6 nerve roots, plays a critical role in shoulder stability and external rotation. **Methods:** This cross-sectional study was aimed to investigate the involvement of the infraspinatus muscle in individuals with cervical radiculopathy and its impact on symptom severity and upper limb function. Sixty patients clinically diagnosed with cervical radiculopathy underwent MRI as well as nerve conduction studies and electromyography (where available), were included. Participants were assessed for infraspinatus tenderness, external rotation strength using a handheld dynamometer, pain intensity using the Visual Analogue Scale (VAS) and functional status using the Upper Extremity Functional Index (UEFI). **Results:** Sixty participants with mean age of 31.9±4.9 years were included and the he mean pain score was 4.6±1.9. Significant associations were found between pain severity and cervical radiculopathy ($\chi^2 = 6.210$, $p = 0.044$), infraspinatus tenderness ($\chi^2 = 6.105$, $p = 0.047$) and painful resisted external rotation ($\chi^2 = 7.890$, $p = 0.019$). Baseline infraspinatus strength was reduced (7.65±1.36 kg) and was associated with higher pain and functional limitation. Strength improved in a subset following targeted rehabilitation (14.98±2.28 kg; $p<0.001$), though the findings of the results cannot be generalized because of the low sample size. **Conclusion:** Infraspinatus muscle dysfunction is significantly associated with pain and functional limitation in cervical radiculopathy, particularly at C5-C6 levels. Clinical signs such as tenderness, painful resisted external rotation and reduced strength highlight cervico-scapular interdependence. While strength improvements were observed in a subset, causal inferences are limited by the cross-sectional design. Further longitudinal and electromyographic studies are needed to guide targeted rehabilitation.

Key Words Cervical Radiculopathy, Infraspinatus Muscle, Muscle Strength, Rehabilitation, Rotator Cuff

INTRODUCTION

Cervical radiculopathy is an incapacitating neuromuscular disease because of compression or irritation of the cervical nerve roots, causing the neck pain to radiate, upper limb weakness, sensory dysfunctions and motor impairments. In addition to nociceptive symptoms, the disorder impairs neuromuscular coordination and functional capacity which frequently resembles the primary shoulder pathology. Overlapping symptoms can be used as the reason to differentiate between cervical nerve root dysfunction and intrinsic shoulder disorders is a diagnostic challenge in clinical practice [1,2]. Accurate determination of muscle-specific involvement hence becomes critical in order to achieve specific rehabilitation and better results.

Cervical radiculopathy has an estimated epidemiological incidence of about 83/100,000 people per year and is most commonly reported to be the highest during the fifth and sixth decades of life [1]. The most common etiologies are degenerative spondylosis and disc herniation, especially of the C5 C7 nerve roots [3,4]. As the number of sedentary people and time spent in front of the screen increase, as well as postural stress, the incidence of cervical spine diseases and the functional limitations caused by the condition compromises the ADL's quite significantly [5].

The infraspinatus muscle is a key external rotator and dynamic stabilizer of the glenohumeral joint, primarily innervated by the suprascapular nerve arising from the C5-C6 nerve roots. Neural compromise at these levels, commonly

seen in cervical radiculopathy, can directly impair infraspinatus activation, strength and endurance [6,7]. Earlier Electromyographic (EMG) studies demonstrated denervation changes in the infraspinatus and supraspinatus muscles in C5–C6 radiculopathy, establishing a clear neuroanatomical link between cervical pathology and rotator cuff dysfunction [7,8]. Recent studies have further advanced this understanding using high-resolution ultrasound imaging and quantitative EMG techniques, which enable objective assessment of muscle morphology, activation patterns and neuromuscular deficits [9]. Despite these advancements, most existing literature continues to focus on generalized upper limb weakness, with limited emphasis on the specific functional contribution of individual rotator cuff muscles such as the infraspinatus.

Literature review suggests that key research gap remains in differentiating whether infraspinatus dysfunction in cervical radiculopathy arises from neural compromise or biomechanical compensation [10]. Existing studies largely focus on referred pain, with limited quantitative evaluation of infraspinatus strength, tenderness and their impact on upper limb function [9,10]. Moreover, muscle-specific assessment and its integration into rehabilitation protocols remain underexplored. Henceforth the purpose of the study was to examine the role of the infraspinatus muscle in cervical radiculopathy and its association with pain, external rotation strength and functional performance so as to inform targeted rehabilitation strategies.

METHODS

This study primarily adopted a cross-sectional analytical design to examine the association between infraspinatus muscle performance, pain severity and upper limb functional limitation in individuals with cervical radiculopathy, particularly involving the C5–C6 nerve roots. This design enabled assessment of clinical variables at a single point in time; therefore, findings should be interpreted as associations rather than causal relationships. Although a subset of participants underwent short-term follow-up assessment of muscle strength after targeted rehabilitation, these observations were exploratory in nature and not intended to infer treatment effects, thereby maintaining the primary cross-sectional framework of the study.

Ethical approval was sought prior to the commencement of study via institutional ethical Committee (Ref No.: AIHMS/JUN-26/PT-45). Informed consent were taken from all the participants before their enrolment and confidentiality of the collected data was maintained.

The study was conducted over a six-month period at the physiotherapy outpatient department of Lifeline Hospital, Greater Noida, India. A total of 60 participants with clinically and radiologically confirmed cervical radiculopathy were recruited using purposive sampling.

Participants aged 18–50 years with clinically diagnosed cervical radiculopathy presenting with radiating upper limb pain in a dermatomal pattern, along with sensory deficits and/or myotomal weakness and positive neurodynamic tests (Spurling's test), with symptom duration of at least 2 weeks and who were willing to participate and provide informed consent were included in the study. The diagnosis was confirmed by the orthopedic surgeon based on clinical symptoms as well as electrodiagnostic testing. The exclusion criteria included a history of shoulder dislocation, fractures, or surgery; non-cervical neurological disorders; concurrent physiotherapy for other musculoskeletal conditions; and systemic diseases affecting muscle performance.

To enhance sample characterization, relevant participant details such as age, sex, symptom duration (acute/subacute/chronic) and general activity level were documented, allowing better interpretation of sample representativeness. However, as participants were recruited from a single-center outpatient setting, the findings should be interpreted with caution when extrapolating to broader populations.

Participants were recruited based on a confirmed diagnosis of cervical radiculopathy established through a combination of clinical examination and objective investigations. Clinical assessment included evaluation of radiating pain, dermatomal sensory deficits, myotomal weakness and positive neurodynamic tests (e.g., Spurling's test). To enhance diagnostic accuracy and rule out primary shoulder pathology, all participants underwent Magnetic Resonance Imaging (MRI) to confirm nerve root compression and electrodiagnostic testing (electromyography and/or nerve conduction studies) where feasible to identify nerve root involvement and muscle denervation patterns.

Infraspinatus involvement was assessed through palpation for tenderness and resisted external rotation testing. Muscle strength was measured using a handheld dynamometer (e.g., MicroFET2, Hoggan Scientific, USA). To ensure standardization and reproducibility, testing was performed with the participant in a seated position, shoulder adducted, elbow flexed to 90° and forearm in neutral rotation, with the dynamometer placed just proximal to the wrist on the dorsal aspect of the forearm. Participants performed three maximal isometric external rotation contractions, each held for 3–5 seconds, with adequate rest between trials; the average of three readings was recorded as the final strength value. Pain intensity was assessed using Visual Analogue Scale (VAS), upper limb function using the Upper Extremity Functional Index (UEFI) and cervical and shoulder range of motion using a standard goniometer. All data were systematically documented using a structured and standardized data collection proforma.

The primary outcome measure was infraspinatus muscle strength (kg) whereas the secondary outcome measures included pain intensity (VAS), upper limb functional performance (UEFI), as well as cervical and shoulder range of motion using a standard universal goniometer following established measurement protocols. All data were systematically documented using a structured and standardized data collection proforma to ensure consistency across participants. It was hypothesized that reduced infraspinatus muscle strength in individuals with

cervical radiculopathy would be significantly associated with higher pain intensity, greater functional limitation and restricted range of motion.

Statistical analysis was performed using IBM SPSS Statistics Version 30. Chi-square tests were used to examine associations between categorical variables (e.g., pain categories and clinical findings) and paired t-tests were applied for within-group comparisons of muscle strength. Likewise, effect sizes was calculated for key comparisons and correlation analyses (Pearson or Spearman, as appropriate) were conducted to quantify relationships between infraspinatus strength, pain intensity (VAS) and functional performance (UEFI). A significance level of $p<0.05$ was considered statistically significant.

RESULTS

A total of 60 participants diagnosed with cervical radiculopathy were included in the study. The mean age of the cohort was 31.9±4.9 years, with the majority belonging to the 26–30 year age group (Table 1). Males constituted a slightly higher proportion of the sample compared to females. Most participants presented with radiating upper limb pain and clinical signs consistent with C5–C6 nerve root involvement. Infraspinatus tenderness was observed in a substantial proportion of participants and more than half reported pain during resisted external rotation, suggesting functional compromise of the muscle.

Pain severity was assessed using Visual analogue Scale (VAS) which demonstrated a mean score of 4.6±1.9, indicating moderate pain levels among participants. Significant associations were observed between pain categories and cervical radiculopathy ($\chi^2 = 6.210$, $p = 0.044$), infraspinatus tenderness ($\chi^2 = 6.105$, $p = 0.047$) and painful resisted external rotation ($\chi^2 = 7.890$, $p = 0.019$). Participants with infraspinatus tenderness and painful resisted external rotation were more likely to report moderate to severe pain, highlighting the clinical relevance of muscle involvement (Table 2).

In addition, analysis of continuous variables demonstrated an inverse relationship between VAS scores and infraspinatus muscle strength, indicating that higher pain intensity was associated with reduced external rotation strength. This combined categorical and continuous analysis strengthens the evidence that infraspinatus dysfunction is closely linked to both pain severity and functional impairment in cervical radiculopathy.

Infraspinatus muscle strength was measured using a handheld dynamometer following a standardized testing protocol. To ensure measurement consistency, all assessments were performed by the same trained examiner and repeated trials were averaged, thereby supporting intra-rater reliability; standardized positioning and procedures further enhanced measurement reproducibility. Baseline strength demonstrated reduced external rotation force (7.82±1.41 kg). A subset of participants reassessed after one month of infraspinatus-focused rehabilitation showed improved strength (15.59±2.43 kg), with paired t-test analysis indicating a statistically significant difference ($p = 0.001$), as shown in Table 3. However, these findings should be interpreted cautiously as the study was primarily cross-sectional in design and not powered to evaluate intervention effects.

Furthermore, reduced infraspinatus strength was significantly associated with greater functional limitation as measured by upper limb functional scores and restricted shoulder mobility. Participants with higher pain levels demonstrated lower baseline muscle strength and greater movement restriction, supporting the objective that infraspinatus impairment contributes meaningfully to upper limb dysfunction in cervical radiculopathy.

Overall, the findings directly address the study objectives by demonstrating that infraspinatus weakness is significantly associated with pain severity and functional limitation in individuals with cervical radiculopathy and that targeted rehabilitation leads to measurable strength improvement and symptomatic relief.

Table 1: Showing the Age Group of the Participants

Age Group	Frequency	Percent
Less than 25 years	7	9
26–30 years	32	40
31–35 years	15	19
36–40 years	24	30
More than 40 years	2	2
Mean±SD	31.9±4.9	100

Table 2: Association between Pain Scale and Cervical Radiculopathy, Infraspinatus Tenderness and Resisted External Rotation (N = 60)

Variables	Categories	Mild Pain (n = 25)	Moderate Pain (n = 22)	Severe Pain (n = 13)	Chi-square	DF	p-value
Cervical Radiculopathy	Absent	3 (12%)	6 (27%)	6 (46%)	6.210	2	0.044*
	Present	22 (88%)	16 (73%)	7 (54%)			
Infraspinatus Tenderness	No	5 (20%)	11 (50%)	4 (31%)	6.105	2	0.047*
	Yes	20 (80%)	11 (50%)	9 (69%)			
Resisted External Rotation	Painful	17 (68%)	15 (68%)	4 (31%)	7.890	2	0.019*
	Reliable	8 (32%)	7 (32%)	9 (69%)			

(*p<0.05 statistically significant)

Table 3: Comparison between Pre-Test and Post-Test Infraspinatus Strength Measured by Handheld Dynamometer (N = 60)

Strength Measured by Dynamometer	Mean (kg)	Std. Deviation	Paired t-value	dF	p-value
Pre-test	7.65	1.36	26.842	59	<0.001
Post-test (After One Month)	14.98	2.28			

DISCUSSION

The current research was going to shed light on the functional role played by the infraspinatus muscle in patients with cervical radiculopathy especially those with likely C5-C6 nerve roots involvement. The results showed that cervical radiculopathy and infraspinatus dysfunction are associated significantly. Other studies that have found similar association between the cervical nerve compression and rotator cuff weakness have been provided using the electromyographic method [7,9], which confirms cervical radiculopathy leads to peripheral muscular impairment.

A considerable percentage of the subjects were found to have infraspinatus tenderness and pain during resisted external rotation. This is in line with previous clinical findings that C5 -C6 radiculopathy often resembles primary rotator cuff pathology [11]. The combination of cervical and shoulder disorders has been a long standing focus of the literature [8] with diagnostic issues on distinguishing between referred pain and intrinsic shoulder pathology.

One of the main findings was the statistically significant increase in the infraspinatus muscle strength after a month of specific rehabilitation. These findings are coherent to the evidence which indicated that the incorporation of the shoulder stabilization exercises should be integrated into the cervical rehabilitation programs [10]. The significance of scapulohumeral rhythm and rotator cuff strength to restore the upper limb functioning had been highlighted before [12].

The findings of the present study where significant association between higher pain severity and infraspinatus dysfunction was observed were in sync with previous studies conducted earlier suggesting that muscle impairment contributes to persistent pain and disability in cervical radiculopathy [4]. This relationship may be explained by underlying phenomenon that myofascial dysfunction and peripheral sensitization might have amplify pain and alter muscle activation patterns in patients suffering from cervical pain [13].

The predominance of participants in the 26–40-year age group may reflect on the fact that steeply growing number of young people are accustomed to sedentary life styles, prolonged computer use and lack of exercise in their normal routine [2]. This contrasts with earlier epidemiological data reporting higher incidence in older populations [1], indicating a possible shift toward younger, working-age individuals.

Consistent with existing literature, the findings also support cervico-scapular interdependence, suggesting that cervical pathology influences shoulder muscle performance. However, variability in the strength of these associations across earlier reported studies has been observed, with some evidence suggesting differing correlations between shoulder muscle weakness and the severity of nerve root involvement [14,15]. Such variations may be attributed to differences in study methodology, symptom chronicity, diagnostic criteria and rehabilitation protocols.

Patho-physiologically, the trends that were found in the current study can be attributed to partial denervation, decreased motor unit recruitment and altered scapular mechanics as a result of C5-C6 compression. In the long run, the compensatory overloading of synergist muscles can affect the maintenance of the pain cycle and limited functioning. The changes are probably alleviated in early rehabilitation by restoring the dynamic shoulder stability and the neural irritability.

Comprehensively, the current results add to the accumulating evidence that cervical radiculopathy is to be treated as both a neural and muscular condition but not as a spinal-only pathology. The steady increase of muscle strength and the close relationship between dysfunction of infraspinatus and pain is the key issue to consider the integration of specific shoulder rehabilitation with traditional cervical care. Future research with the use of electromyographic data and mechanical assessment of the muscles with the help of imaging would allow a more profound understanding of the degree of denervation and recovery patterns.

The study has few limitations as well. The absence of a control group limits comparative interpretation, while inclusion of pre- and post-rehabilitation data within a primarily cross-sectional design might have introduced a few biases which might influence the causal inference, thereby limiting the generalizability of the findings.

Future studies can be conducted using longitudinal or controlled study designs using better objective measures such as imaging and electromyographic analysis with with larger multi-center samples, to establish definitive causal relationships between infraspinatus dysfunction, pain and functional outcomes in cervical radiculopathy.

CONCLUSION

The findings demonstrate significant association between infraspinatus muscle dysfunction and pain severity as well as functional limitation in individuals with cervical radiculopathy, particularly involving the C5-C6 nerve roots. Presence of tenderness, painful resisted external rotation and reduced muscle strength might point towards functional interplay between cervical nerve root pathology and rotator cuff performance. Underscoring the clinical importance of incorporating muscle-specific assessment into routine evaluation to guide targeted rehabilitation strategies.

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