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ORIGINAL ARTICLE

Electromyographic Analysis of Rotator Cuff Muscle Activity During Shoulder Immobilization: Standard Sling versus Abduction Sling in Filipinos

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ABSTRACT

Objectives. To compare supraspinatus and infraspinatus muscle activity using needle electromyography (EMG) between a standard arm sling and an abduction sling in healthy Filipino adults.

Methodology. This experimental pilot study included 34 healthy Filipino adults aged 18–40 years without prior shoulder pathology. Needle electromyography was performed by a single licensed and experienced electromyographer. Baseline electromyographic recordings obtained during active shoulder forward flexion, abduction, and external rotation confirmed appropriate muscle activation and correct needle placement before immobilization testing. Motor unit action potential (MUAP) recruitment and amplitude were evaluated under two immobilization conditions: a standard arm sling with the shoulder positioned in internal rotation and adduction, followed by an abduction sling positioned at approximately 30° of shoulder abduction with slight external rotation.

Results. Thirty-four participants completed the study. The study population consisted of 21 males (61.8%) and 13 females (38.2%), with a mean age of 28.9 ± 5.5 years. Twenty-eight participants (82.4%) were right-hand dominant, while six (17.6%) were left-hand dominant. Baseline electromyographic recordings demonstrated normal motor unit recruitment in both target muscles. During resting immobilization, complete absence of detectable motor unit recruitment and MUAP amplitude was observed in both the supraspinatus and infraspinatus muscles under both the standard arm sling and abduction sling conditions. Identical electromyographic findings were demonstrated in all participants regardless of the immobilization method.

Conclusion. Both the standard arm sling and the abduction sling demonstrated complete electromyographic quiescence of the supraspinatus and infraspinatus muscles during resting immobilization. Neither immobilization method demonstrated a measurable advantage over the other with respect to resting electromyographic muscle activity. However, because this study evaluated muscle electrical activity rather than passive tendon tension, these findings should not be interpreted as evidence of biomechanical equivalence between sling positions. Further prospective studies involving postoperative rotator cuff repair patients are warranted.

Keywords. rotator cuff, electromyography, shoulder immobilization, arm sling, abduction arm sling

INTRODUCTION

Rotator cuff tears are a frequent cause of shoulder pain and weakness, with prevalence increasing with age and affecting approximately 30–50% of individuals over 50 years.[1] Several factors influence outcomes following rotator cuff repair, including tear size, location, muscle atrophy, tendon quality, repair tension, smoking status, and postoperative rehabilitation.[2-4] Despite advances in surgical management, there remains no clear consensus regarding optimal postoperative immobilization strategies.[5,6] Postoperative shoulder immobilization plays a critical role in protecting the repaired tendon during the early phases of healing by minimizing excessive mechanical stress across the repair construct. Among the available methods, the abduction sling has traditionally

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been favored because biomechanical studies have demonstrated reduced passive tension and gap formation across the repaired supraspinatus tendon when the shoulder is maintained in slight abduction and external rotation.[7-11] However, despite these biomechanical advantages, randomized clinical trials and systematic reviews have demonstrated comparable pain scores, functional outcomes, tendon healing rates, and retear rates compared with standard arm slings.[2,7,12-14]

Electromyography (EMG) is an objective method for evaluating muscle activation by recording electrical activity generated by motor units.[6] The motor unit action potential (MUAP) reflects the combined electrical activity of muscle fibers within a motor unit.[15] EMG has been widely used to assess muscle function and guide rehabilitation, particularly in postoperative settings.[4] Needle electromyography permits selective evaluation of deep muscles such as the supraspinatus and infraspinatus, which cannot be reliably isolated using surface electrodes because of signal contamination from adjacent musculature.[16,17] However, there is limited evidence comparing rotator cuff muscle activity across different immobilization positions. Furthermore, passive tendon loading and active muscle contraction represent distinct biomechanical mechanisms. Although shoulder position may influence passive tension across the repaired tendon, electromyography measures only the electrical activity generated by muscle contraction and therefore provides complementary information regarding postoperative muscle quiescence.[9-11,17]

This study aimed to compare rotator cuff muscle activity between a standard arm sling and an abduction sling using EMG in a Filipino population. To our knowledge, no published study has compared electromyographic activity of the supraspinatus and infraspinatus muscles between a standard arm sling and an abduction sling in a Filipino population. Establishing baseline electrophysiologic data among healthy Filipino adults may provide locally relevant evidence to guide future investigations involving postoperative rotator cuff repair patients and contribute to evidence-based shoulder rehabilitation protocols. This study sought to establish baseline data and identify the immobilization position that minimizes voluntary muscle activation of the supraspinatus and infraspinatus muscles during resting shoulder immobilization.

METHODOLOGY

The study protocol was approved by the Institutional Review Board of a tertiary hospital (IRB No. 2022-33-01-A) and was conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment. The experimental pilot study was conducted at the Electromyography-Nerve Conduction Study (EMG-NCS).

A total of 34 participants were recruited based on a priori sample size calculation using G*Power version 3.1 with an alpha level of 0.05 and a statistical power of 80%. Healthy Filipino adults aged 18–40 years without prior shoulder injury or surgery involving the dominant limb were included. To minimize the possibility of including participants with asymptomatic rotator cuff pathology, only young adults were recruited. For consistency and standardization of the examination, only the dominant shoulder of each participant was evaluated. Participants were screened clinically to exclude shoulder pathology using standard shoulder examination protocols.[18] The clinical evaluation included inspection for deformity and muscle atrophy, palpation for tenderness, assessment of active and passive range of motion, rotator cuff muscle strength testing using a handheld dynamometer, and examination for shoulder instability and impingement. Participants demonstrating pain, weakness, restricted range of motion, instability, or any clinical findings suggestive of rotator cuff pathology were excluded from the study.

Needle electromyography was performed by a single licensed and experienced electromyographer using a Cadwell Sierra Summit® 2-Channel electromyography system (Cadwell Laboratories, Kennewick, WA, USA) and sterile disposable monopolar EMG needle electrodes (PRO-37SAF, 37 mm × 27 gauge; The Electrode Store, Buckley, WA, USA). Standard EMG settings include sensitivity of 100μV per division and sweep speed of 10 milliseconds per division. Needle electromyography was selected instead of surface electromyography because the supraspinatus and infraspinatus are deep muscles that cannot be reliably isolated using surface electrodes due to signal contamination from adjacent musculature. Needle EMG permits selective assessment of individual rotator cuff muscles and remains the reference standard for evaluating motor unit activity in deep muscles.[4,16,17]

Prior to immobilization, baseline needle electromyographic recordings were obtained during active shoulder forward flexion, abduction, and external rotation to confirm appropriate muscle localization and correct needle placement. Demonstration of normal motor unit recruitment during these maneuvers confirmed accurate localization of the target muscles before recordings under resting conditions were performed.

Participants were comfortably seated in a straight-backed examination chair with back support, both feet resting flat on the floor, and the trunk maintained in an upright neutral position. The standard arm sling was applied first with the shoulder positioned in internal rotation and adduction, followed by the abduction sling positioned at approximately 30° of shoulder abduction with slight external rotation. Following application of each immobilization device, a standardized 5-minute accommodation period was observed to allow proper sling fit, maintenance of the intended shoulder position, and participant comfort before electromyographic recordings were obtained. Recordings were performed only after participants confirmed that they were comfortable and no further sling adjustments were required (Figure 1).

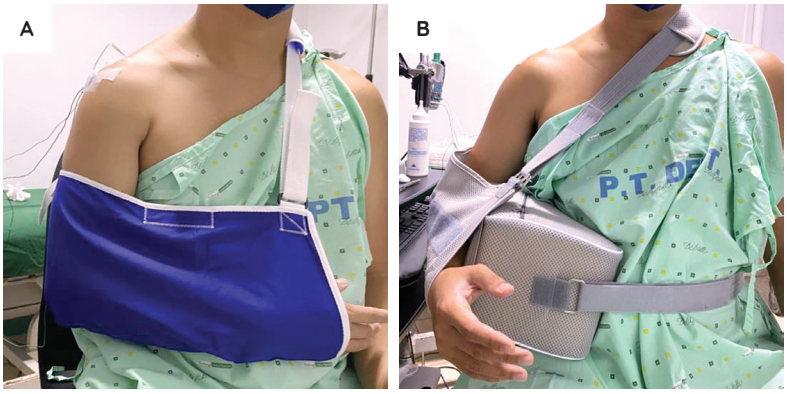


Figure 1. Immobilization techniques of the upper limb used in the study. Standard arm sling: the shoulder is adducted, the arm is on the side and the forearm rests on the anterior torso **(A)**. Abduction arm sling: arm is approximately 30° abducted and the shoulder is in slightly external rotation **(B)**.

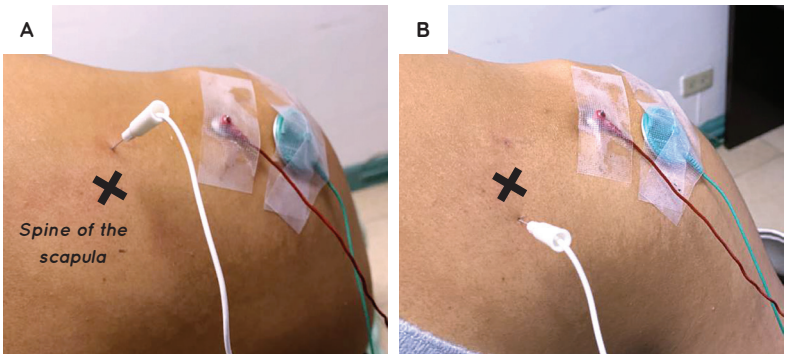


Figure 2. Anatomic placement of needle electrodes. A single disposable needle electrode was inserted at separate times into the supraspinatus and infraspinatus muscles. Needle electrodes were inserted into the supraspinatus 1.5 cm superior to the midpoint of spine of the scapula **(A)** and into the infraspinatus 2.5 cm inferior to the midpoint of spine of the scapula **(B)**.

Needle electrodes were inserted into the supraspinatus and infraspinatus muscles individually using standard anatomical landmarks (Figure 2). Needle electrodes were then inserted into the supraspinatus 1.5 cm superior to the midpoint of spine of the scapula and into the infraspinatus 2.5 cm inferior to the midpoint of spine of the scapula, for isolated EMG testing.

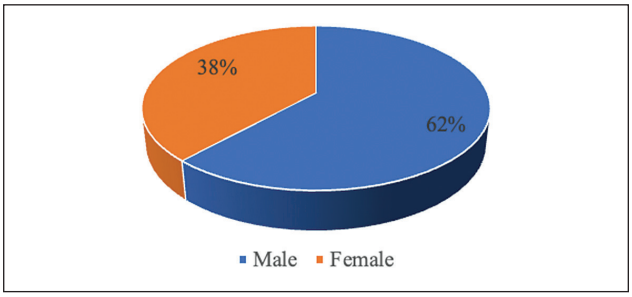


Figure 3. Distribution of participants according to sex.

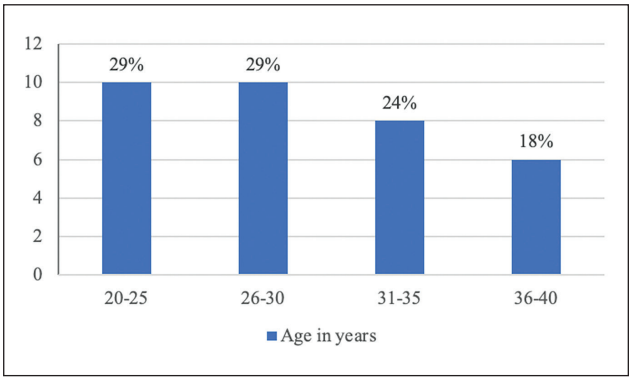


Figure 4. Distribution of participants according to age group.

All examinations were performed by the same electromyographer under identical testing conditions and standardized recording parameters to maximize reproducibility and minimize measurement variability.

The primary outcome measures were MUAP recruitment and amplitude under both immobilization conditions. Electromyographic recordings were evaluated for the presence or absence of spontaneous motor unit recruitment and measurable MUAP amplitude during resting shoulder immobilization.

Data were summarized using descriptive statistics. Continuous variables are presented as mean ± standard deviation, whereas categorical variables are presented as frequencies and percentages. Because all EMG recordings demonstrated absence of activity (zero values) in both conditions, inferential statistical comparisons were not applicable. Since no variability existed within the electromyographic dataset, hypothesis testing was not performed.

RESULTS

Thirty-four participants successfully completed the study protocol. The study population consisted of 21 males (61.8%) and 13 females (38.2%), with a mean age of 28.9 ± 5.5 years (range, 20–39 years) (Figures 3 and 4). Twenty-eight participants (82.4%) were right-hand dominant, while six (17.6%) were left-hand dominant (Figure 5).

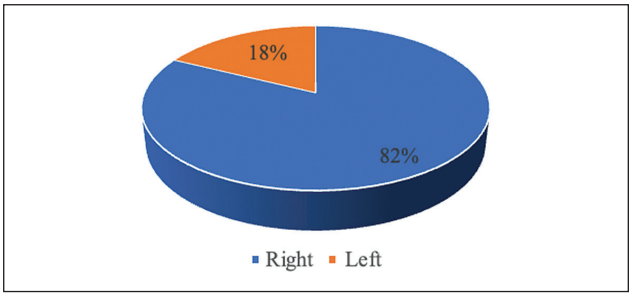


Figure 5. Distribution of participants according to handedness.

Baseline needle electromyographic recordings obtained during active shoulder forward flexion, abduction, and external rotation demonstrated normal motor unit recruitment in both the supraspinatus and infraspinatus muscles in all participants, confirming appropriate muscle localization and correct needle placement before immobilization testing (Figures 6 and 7).

During resting immobilization, electromyographic analysis demonstrated complete absence of detectable motor unit recruitment and motor unit action potential (MUAP) amplitude in both the supraspinatus and infraspinatus muscles under both the standard arm sling and abduction sling conditions (Tables 1 and 2). Identical findings were observed in all participants, demonstrating complete electromyographic quiescence regardless of immobilization method. Because all recordings demonstrated uniformly absent electromyographic activity, no variability existed within the dataset; therefore, inferential statistical analysis was not performed.

DISCUSSION

Various shoulder immobilization methods are used in clinical practice, yet no universally accepted postoperative protocol exists following rotator cuff repair.[5,19] While immobilization is traditionally recommended during the early postoperative period to protect the repair and facilitate tendon healing,[20] early mobilization has also been proposed to improve functional recovery without compromising repair integrity in selected patients.[5,21]

The mechanical environment plays a critical role in tendon healing, with increased repair-site tension associated with

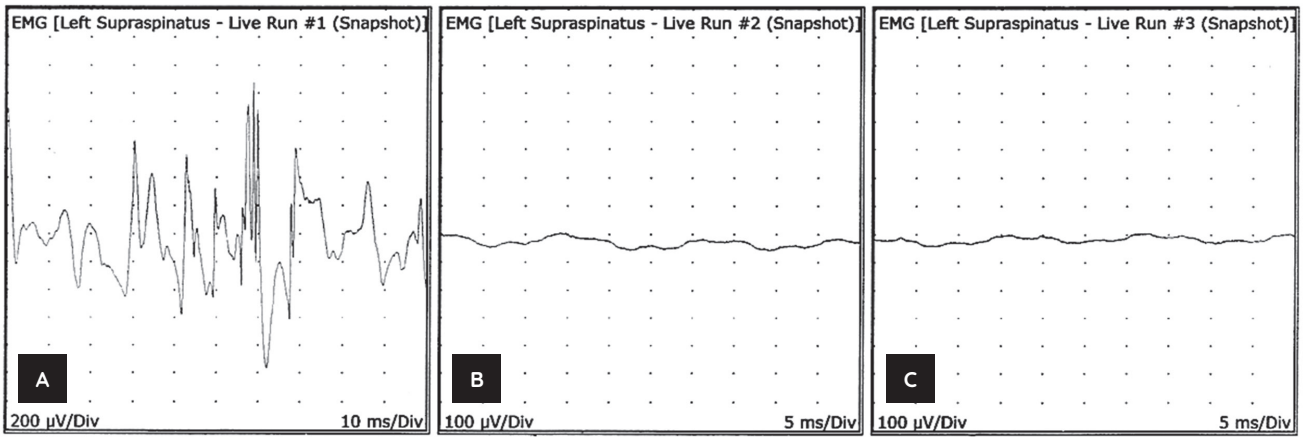


Figure 6. Sample electromyography waveforms of the supraspinatus muscle. During active shoulder movement **(A)**, with standard arm sling **(B)**, and with abduction sling **(C)**.

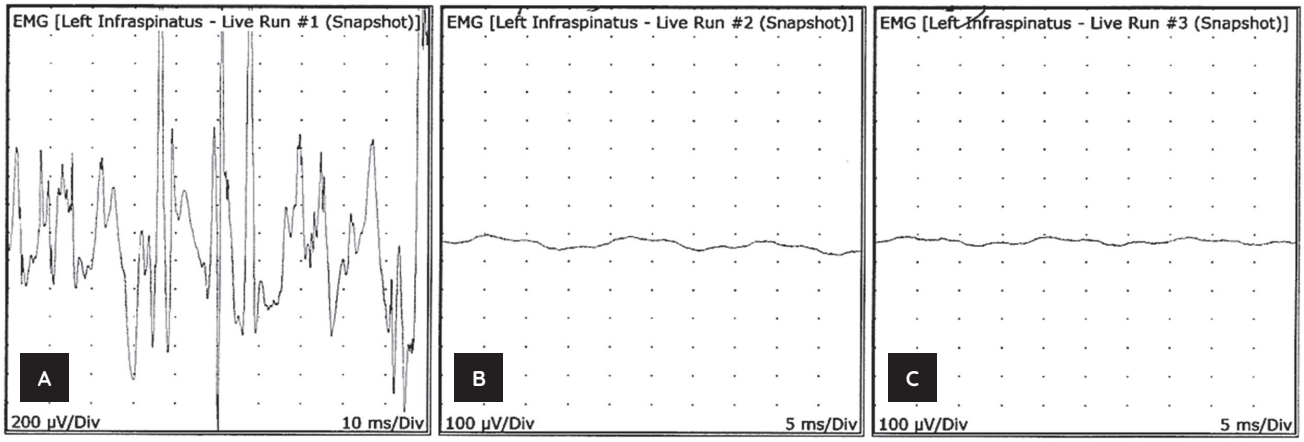


Figure 7. Sample electromyography waveforms of the infraspinatus muscle. During active shoulder movement **(A)**, with standard arm sling **(B)**, and with abduction sling **(C)**.

Table 1. Comparison of motor unit action potentials of the supraspinatus muscle

Participant	Standard Arm Sling		Abduction Sling	
	MUAP		MUAP	
	Recruitment (Hz)	Amplitude (mV)	Recruitment (Hz)	Amplitude (mV)
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0
17	0	0	0	0
18	0	0	0	0
19	0	0	0	0
20	0	0	0	0
21	0	0	0	0
22	0	0	0	0
23	0	0	0	0
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0
27	0	0	0	0
28	0	0	0	0
29	0	0	0	0
30	0	0	0	0
31	0	0	0	0
32	0	0	0	0
33	0	0	0	0
34	0	0	0	0

MUAP, motor unit action potential

Table 2. Comparison of motor unit action potentials of the infraspinatus muscle

Participant	Standard Arm Sling		Abduction Sling	
	MUAP		MUAP	
	Recruitment (Hz)	Amplitude (mV)	Recruitment (Hz)	Amplitude (mV)
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0
17	0	0	0	0
18	0	0	0	0
19	0	0	0	0
20	0	0	0	0
21	0	0	0	0
22	0	0	0	0
23	0	0	0	0
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0
27	0	0	0	0
28	0	0	0	0
29	0	0	0	0
30	0	0	0	0
31	0	0	0	0
32	0	0	0	0
33	0	0	0	0
34	0	0	0	0

MUAP, motor unit action potential

a greater risk of structural failure.[12] Biomechanical studies have demonstrated that positioning the shoulder in slight abduction decreases passive strain across the repaired supraspinatus tendon and reduces gap formation at the repair site.[8-11] Consequently, abduction slings have traditionally been recommended, particularly following repair of large or massive rotator cuff tears. However, randomized clinical trials and systematic reviews have reported no significant differences in postoperative pain, functional outcomes, tendon healing, or retear rates between patients treated with standard arm slings and those managed with abduction slings.[2,7,12-14]

The present study evaluated electromyographic muscle activity rather than passive tendon tension, and this distinction is fundamental when interpreting the findings. Passive tendon loading and active muscle contraction represent separate biomechanical mechanisms. Although shoulder position may influence passive tension across the repaired tendon, electromyography measures only the electrical activity generated by muscle contraction. Consequently, the complete absence of electromyographic activity observed under both immobilization conditions indicates successful suppression of voluntary supraspinatus and infraspinatus muscle activation during resting immobilization but should not be interpreted as evidence that both immobilization methods produce identical passive biomechanical loading of the repaired tendon.

The present study provides objective electrophysiologic evidence that both the standard arm sling and the abduction

sling eliminate detectable rotator cuff muscle activity during resting immobilization. Because electromyographic activity was uniformly absent across all participants under both conditions, meaningful statistical comparison was not possible owing to the absence of variability in the recorded outcomes.

Our findings complement previous biomechanical investigations rather than contradict them. Whereas earlier studies demonstrated reduced passive tendon strain with shoulder abduction, the present study demonstrates that both immobilization methods effectively eliminate detectable supraspinatus and infraspinatus muscle activation during resting conditions. Together, these findings suggest that passive tendon tension and muscle electrical activity should be regarded as complementary rather than interchangeable considerations when selecting postoperative immobilization strategies.

These findings are particularly relevant during the early postoperative period, when minimizing mechanical stress on the repair construct is critical for tendon healing. Although the present study did not directly evaluate postoperative patients or tendon biomechanics, the demonstration of complete electromyographic quiescence under both immobilization conditions suggests that either sling effectively suppresses voluntary rotator cuff muscle activation while the shoulder remains at rest.

From a clinical perspective, these findings support a more individualized approach to postoperative immobilization. Selection of the immobilization device should continue to consider tear characteristics, repair configuration, surgeon preference, patient comfort, compliance, availability, and cost rather than relying solely on theoretical differences in muscle activation. This is particularly relevant in resource-limited environments such as the Philippines, where the lower cost and wider availability of a standard arm sling may improve patient adherence without compromising electromyographic muscle quiescence during resting immobilization.

Several strengths of the present study should be acknowledged. Needle electromyography remains the reference standard for evaluating motor unit activity in deep muscles such as the supraspinatus and infraspinatus. All examinations were performed by a single experienced electromyographer using a standardized protocol, thereby minimizing interobserver variability. Baseline muscle activation confirmed appropriate muscle localization and correct needle placement before immobilization testing, while identical participant positioning, recording conditions, and examination sequence enhanced the reproducibility of the findings.

Limitations of the study include the use of healthy participants rather than postoperative patients and the relatively small sample size. Electromyographic activity was evaluated only during resting immobilization and did not include dynamic shoulder movement or rehabilitation exercises. Passive tendon tension was not directly measured; therefore, biomechanical differences between immobilization methods cannot be inferred solely from electromyographic findings. Although participants underwent standardized clinical screening to exclude shoulder pathology, advanced imaging such as magnetic resonance imaging or ultrasonography was not routinely performed to exclude asymptomatic rotator cuff abnormalities. Finally, participants were evaluated sequentially using the standard arm sling followed by the abduction sling without randomization of the testing order. Although identical findings were obtained under both conditions, the possibility of an order effect cannot be completely excluded.

Future prospective studies involving postoperative rotator cuff repair patients should integrate electromyographic assessment with biomechanical measurements, imaging evaluation of tendon healing, and validated clinical outcome measures to further define the relationship between muscle quiescence, passive tendon tension, and optimal postoperative shoulder immobilization.

CONCLUSION

Both standard arm sling and abduction sling immobilization positions resulted in complete electromyographic quiescence of the supraspinatus and infraspinatus muscles during resting shoulder immobilization in healthy Filipino adults. Neither immobilization method demonstrated a measurable advantage over the other with respect to resting electromyographic muscle activity.

However, because this study evaluated muscle electrical activity rather than passive tendon tension, these findings should not be interpreted as evidence of biomechanical equivalence between sling positions.

Postoperative immobilization should therefore continue to be individualized according to tear characteristics, surgical technique, biomechanical requirements, surgeon preference, patient comfort, compliance, availability, and cost.

Further prospective studies involving postoperative rotator cuff repair patients incorporating electromyographic, biomechanical, imaging, and clinical outcome assessments are warranted.

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STATEMENT OF AUTHORSHIP

All authors certified fulfillment of ICMJE authorship criteria.

CREDIT AUTHOR STATEMENT

RAAE: Conceptualization, Methodology, Formal Analysis, Investigation, Data Curation, Writing – Original Draft, Visualization, Project Administration; **JMOA:** Conceptualization, Methodology, Validation, Investigation, Resources, Data Curation, Writing – Review and Editing; **JCR:** Conceptualization, Methodology, Validation, Supervision, Writing – Review and Editing; **RNE:** Conceptualization, Methodology, Formal Analysis, Validation, Supervision, Writing – Review and Editing.

DATA AVAILABILITY STATEMENT

The datasets generated and analyzed in this study are included in the published article.

AUTHOR DISCLOSURE

The authors declared no conflict of interest.

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None.

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