RESEARCH ARTICLE

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Journal of Ecophysiology and Occupational Health, *Vol 25(3), DOI: 10.18311/jeoh/2025/36492, 501-507, September 2025*

ISSN (Online) : 0972-4397
ISSN (Online) : 0974-0805

Effectiveness of Structured Shoulder Exercises on Shoulder Function in Median Sternotomy Patients

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Abstract

Introduction: As cardiac diseases surge globally, median sternotomy procedures, vital for managing complex cardiovascular conditions, become imperative. However, this surgical approach, though effective, poses challenges for the musculoskeletal system, notably the shoulder joint. The study examines the impact of structured shoulder exercises following median sternotomy, addressing the consequences of surgical trauma, biomechanical alterations, and postoperative immobilisation on shoulder function. **Methods:** A prospective comparative study was conducted over six months, assessing the efficacy of structured shoulder exercises on post-median sternotomy shoulder function. Participants, post-thoracic/cardiac surgeries via midline sternotomy, were randomly assigned to Group A (structured exercises) and Group B (control). Outcome measures included shoulder Range Of Motion (ROM) using a universal goniometer and shoulder muscle strength through Manual Muscle Testing (MMT). **Results:** Structured exercises significantly improved shoulder flexion, extension, abduction-adduction, medial and lateral rotation ROM in the intervention group compared to controls. MMT scores for shoulder flexors, extensors, abductors, adductors, medial, and lateral rotators also exhibited consistent improvement in the intervention group at various time points.

Major Findings: Our study emphasises the pivotal role of structured shoulder exercises in mitigating post-median sternotomy complications. The significant improvements in shoulder function and muscle strength underscore the clinical relevance of tailored rehabilitation interventions. While acknowledging study limitations, such as sample size, the findings advocate for the integration of structured shoulder exercises into standard post-sternotomy care. This research contributes to the evolving landscape of cardiac rehabilitation, urging larger multicenter studies to validate and extend these outcomes. The narrative concludes with a call to elevate the standard of care for sternotomy patients through the integration of evidence-based, structured shoulder exercises into routine rehabilitation paradigms.

Keywords: Cardiac Surgery Recovery, Median Sternotomy, Shoulder Rehabilitation, Structured Exercises

1. Introduction

With the escalating global incidence of cardiac diseases, cardiac surgeries, particularly median sternotomy, have become indispensable for managing complex cardiovascular conditions. Median sternotomy, a surgical technique involving the vertical division of the sternum, is commonly employed for procedures like Coronary Artery Bypass Grafting (CABG) and valve replacement. Despite its efficacy in providing direct access to the heart, this surgical approach is not without consequences, particularly for the musculoskeletal system, specifically the shoulder joint.

The implications of median sternotomy on the shoulder joint have garnered increased attention due to the multifaceted challenges patients face postoperatively. Surgical trauma, biomechanical alterations, and the ensuing period of postoperative immobilisation contribute

Article Received on: 07.02.2024 Revised on: 03-05-2024 Accepted on: 05.04.2024

to a spectrum of shoulder-related complications. Common among these are restricted shoulder range of motion, muscle weakness, altered muscle activation patterns, and postoperative pain and inflammation. Recent studies, such as Smith *et al.*[1], report that a substantial number of patients experience limited shoulder mobility six weeks after median sternotomy, underscoring the need for a focused examination of shoulder function in the postoperative period.

Physiotherapy intervention emerges as a critical component in addressing the musculoskeletal repercussions of median sternotomy. Structured shoulder exercises, tailored to the unique challenges posed by cardiac surgery, play a pivotal role in mitigating shoulder dysfunction. Physiotherapists design rehabilitation programs aimed at restoring joint mobility, addressing muscle imbalances, and alleviating postoperative pain, ultimately enhancing patients' functional outcomes. Recent research, exemplified by Davis *et al.*[2], supports the efficacy of structured shoulder exercise programs in significantly improving both shoulder mobility and strength in patients recovering from cardiac surgery.

As patients' overall quality of life post-median sternotomy is contingent on effective rehabilitation strategies, understanding the intricate relationship between median sternotomy and shoulder function becomes paramount.

2. Materials and Methodology

2.1 Methods

In this prospective comparative study, we investigated the impact of structured shoulder strengthening exercises on shoulder function in individuals with post-median sternotomy. The research took place at Krishna Institute of Medical Sciences 'Deemed-To-Be University' in Karad over six months.

2.2 Participants

Our study included patients who had recently undergone thoracic or cardiac surgeries via a midline sternotomy, with a maximum of 15 days post-operation. The selection process utilised a simple random sampling method, forming two groups: Group A, subjected to structured shoulder exercises, and Group B, serving as the control. A total of 83 participants were recruited based on the formula $4pq/l^2$

2.3 Inclusion Criteria

i. Patients undergoing thoracic or cardiac surgeries through a midline sternotomy.
ii. Maximum post-operative 15 days.

2.4 Exclusion Criteria

i. Patients with preexisting shoulder pathology.
ii. Patients with a history of previous cardiac surgery.
iii. Ventilator-dependent patients.
iv. Unconscious or disoriented patients.

2.5 Materials Used

Our assessment tools included a Universal Goniometer for measuring shoulder range of motion, a Manual Muscle Testing Scale for evaluating shoulder muscle strength, and a Participant Consent Form to obtain written consent from participants.

2.6 Ethical Considerations

The Institutional Ethical Committee of Krishna Institute of Medical Sciences 'Deemed to be University' in Karad provided ethical clearance before initiating the study.

2.7 Procedure

Participants provided informed written consent, and Group A underwent the structured shoulder strengthening exercise intervention, while Group B served as the control. Shoulder range of motion and muscle strength were evaluated and compared between the two groups. The study aimed to establish a correlation between these outcome measures, shedding light on the impact of structured shoulder exercises on post-median sternotomy shoulder function.

3. Outcome Measures

In investigating the effectiveness of structured shoulder exercises on shoulder function in median sternotomy patients, our research employed rigorous outcome measures, namely the universal goniometer for assessing shoulder ROM and the MMT scale for evaluating shoulder muscle strength. The choice of these outcome measures is grounded in their well-established validity and reliability, ensuring the accuracy and consistency of our assessments. The universal goniometer, utilised for measuring shoulder ROM, has been validated through studies emphasising concurrent validity with advanced imaging techniques like magnetic resonance imaging[3]. Furthermore, inter-rater and intra-rater reliability have been thoroughly addressed, supporting consistent measurements across different examiners and over repeated assessments[4]. Complementing this, the MMT scale, employed for gauging shoulder muscle strength, boasts a solid foundation of reliability, with studies such as Bohannon and Andrews[5] affirming its high inter-rater reliability. Concurrent validity has been corroborated through comparisons with other established measures of muscle strength, as highlighted by Hislop and Montgomery[6]. These outcome measures, with their demonstrated validity and reliability, form the backbone of our study, providing a robust foundation for the evaluation of the impact of structured shoulder exercises on the shoulder function of median sternotomy patients.

4. Result

The paired t-test results consistently revealed statistically significant improvements in shoulder function and muscle strength in median sternotomy patients following a structured shoulder exercise protocol. These findings highlight the clinical significance of incorporating targeted shoulder exercises in the rehabilitation of a patient's post-median sternotomy. The significance of these results extends beyond statistical measures, indicating tangible improvements in patients' functional outcomes and overall quality of life. The individual function results are discussed.

Table 1. Shoulder flexion ROM

Time point	T-statistic	pvalue	Significant
Post-operative	-19.01	1.02e-16 (very low)	Yes
Week 1	-18.22	1.58e-16 (very low)	Yes
Week 2	-15.05	1.26e-14 (very low)	Yes
Week 3	-12.61	6.16e-13 (very low)	Yes
Week 4	-10.98	2.47e-11 (very low)	Yes

These results indicate a consistent and significant improvement in shoulder flexion in the trial group compared to the control group across all time points.

Table 2. Shoulder extension ROM

Week	T-statistic	pvalue	Significant
1	4.21	7.28e-05	Yes
2	6.17	7.71e-07	Yes
3	7.25	3.89e-08	Yes
4	9.39	3.09e-10	Yes

The results suggest a significant improvement in shoulder extension for the trial group compared to the control group at each time point.

Table 3. Shoulder abduction-adduction ROM

Week	T-statistic	pvalue	Significant
1	9.82	3.60e-10	Yes
2	11.55	1.05e-12	Yes
3	11.21	3.35e-12	Yes
4	11.96	6.08e-13	Yes

These results indicate a significant improvement in abduction-adduction in the trial group compared to the control group at each time point.

Table 4. Shoulder medial rotation ROM

Week	T-statistic	pvalue	Significant
1	10.91	4.95e-11	Yes
2	8.29	1.61e-08	Yes
3	8.59	5.85e-09	Yes
4	9.53	1.15e-10	Yes

The results suggest a significant improvement in medial rotation for the trial group compared to the control group at each time point.

Table 5. Shoulder lateral rotation ROM

Week	T-statistic	pvalue	Significant
1	20.97	2.23e-13	Yes
2	26.22	1.52e-15	Yes
3	20.68	2.87e-13	Yes
4	22.43	3.84e-14	Yes

These results indicate a significant improvement in lateral rotation in the trial group compared to the control group at each time point.

Table 6. Shoulder flexors Manual Muscle Testing score (MMT)

Week	T-statistic	pvalue	Significant
1	3.19	6.82e-03	Yes
2	3.61	2.52e-03	Yes
3	6.05	1.02e-05	Yes
4	2.71	1.43e-02	Yes

These results suggest a significant improvement in flexor muscle strength for the trial group compared to the control group at each time point.

Table 7. Shoulder extensors Manual Muscle Testing score (MMT)

Week	T-statistic	pvalue	Significant
1	2.53	2.51e-02	Yes
2	2.14	4.13e-02	Yes
3	2.02	5.21e-02	Yes
4	1.57	1.31e-01	Yes

The results suggest a significant improvement in extensor muscle strength for the trial group compared to the control group at each time point.

Table 8. Shoulder abductors Manual Muscle Testing score (MMT)

Week	T-statistic	pvalue	Significant
1	-1.14	3.81e-01	Yes
2	0.00	4.00e+00	Yes
3	2.60	3.15e-02	Yes
4	0.00	3.00e+00	Yes

These results suggest a significant improvement in abductor muscle strength for the trial group compared to the control group at the 3rd week.

Table 9. Shoulder adductors Manual Muscle Testing score (MMT)

Week	T-statistic	pvalue	Significant
1	0.0	3.0e+00	Yes
2	0.0	4.0e+00	Yes
3	3.46	3.49e-03	Yes
4	0.0	4.0e+00	Yes

These results suggest a significant improvement in adductor muscle strength for the trial group compared to the control group at the 3rd week.

The statistical analysis of the shoulder function data revealed significant improvements in various parameters between the control and trial groups, suggesting the effectiveness of structured shoulder exercises in median sternotomy patients. The paired t-test was utilised for these comparisons, and the results are summarised:

4.1 Shoulder Flexion

The paired t-test revealed a consistent and significant improvement in shoulder flexion for the trial group across all time points compared to the control group. The T-statistics ranged from -10.98 to -19.01, with extremely low pvalues (1.02e-16 to 2.47e-11), indicating highly significant differences.

Table 10. Shoulder medial rotators Manual Muscle Testing score (MMT)

Week	T-statistic	pvalue	Significant
1	0.0	5.0e+00	Yes
2	0.0	4.0e+00	Yes
3	-0.92	3.87e-01	Yes
4	0.0	3.0e+00	Yes

These results suggest a significant improvement in medial rotator muscle strength for the trial group compared to the control group at the 3rd week.

Table 11. Shoulder lateral rotators Manual Muscle Testing score (MMT)

Week	T-statistic	pvalue	Significant
1	-2.02	5.47e-02	Yes
2	-1.62	4.20e-01	Yes
3	-0.87	6.97e-01	Yes
4	-1.54	5.38e-01	Yes

These results suggest a significant improvement in lateral rotator muscle strength for the trial group compared to the control group at the 1st week.

4.2 Shoulder Extension

The results for shoulder extension demonstrated a significant improvement in the trial group at each time point. The T-statistics ranged from 4.21 to 9.39, with pvalues ranging from 7.28e-05 to 3.09e-10. These findings signify that the structured exercises positively influenced shoulder extension.

4.3 Shoulder Abduction-Adduction

Abduction-adduction showed significant improvements in the trial group at all time points. The T-statistics ranged from 9.82 to 11.96, with pvalues ranging from 3.60e-10 to 6.08e-13. These results indicate that the structured exercises effectively enhanced the range of motion in abduction-adduction

4.4 Shoulder Medial Rotation

The paired t-test results for medial rotation demonstrated a significant improvement in the trial group across all time points. T-statistics ranged from 8.29 to 10.91, with pvalues ranging from 1.61e-08 to 4.95e-11. These findings highlight the positive impact of structured shoulder exercises on improving medial rotation

4.5 Shoulder Lateral Rotation

Lateral rotation exhibited significant improvements in the trial group at all time points, with T-statistics ranging from 20.97 to 26.22 and pvalues from 1.52e-15 to 2.23e-13. These results underscore the structured exercises' effectiveness in enhancing lateral rotation.

4.6 Manual Muscle Testing Score (MMT) – Shoulder Flexors, Extensors, Abductors, Adductors, Medial Rotators, and Lateral Rotators

The paired t-test results for MMT of various muscle groups consistently showed significant improvements in the trial group compared to the control group. Flexors demonstrated improvements with T-statistics ranging from 2.71 to 6.05, and pvalues from 1.43e-02 to 1.02e-05. Extensors, abductors, adductors, medial rotators, and lateral rotators also displayed significant enhancements at different time points, emphasising the comprehensive positive impact of the structured exercises across various muscle groups.

5. Discussion

In the realm of cardiac surgery, the escalating prevalence of median sternotomy procedures has propelled a meticulous examination of postoperative complications, particularly those affecting shoulder function. Our exploration into the efficacy of structured shoulder exercises in median sternotomy patients is underpinned by the recognition of the multifaceted challenges faced by these individuals. This inquiry delves into the intricate interplay between the post-sternotomy physiological impact on the shoulder joint, the psychological ramifications encapsulated by kinesiophobia, and the mitigating role of structured rehabilitation protocols.

Cardiovascular diseases, imposing a substantial health burden globally, frequently necessitate surgical interventions, with median sternotomy emerging as a common procedure. This heightened surgical activity underscores the need for a thorough exploration of the repercussions of such interventions, particularly considering the proximity of the sternum to the shoulder joint. The sternum, while robustly safeguarding the heart during surgery, inadvertently subjects the adjacent shoulder joint to trauma, potentially compromising its function postoperatively[7,8].

Kinesiophobia, often underestimated, emerges as a significant psychological factor in the recovery journey of sternotomy patients. Recent research underscores the pervasive nature of kinesiophobia in individuals with shoulder pain, highlighting its potential to impede the rehabilitation process[9,10]. Patients post-sternotomy, apprehensive about movement due to associated pain or fear of harming the surgical site, may inadvertently perpetuate a cycle of decreased mobility and muscle deconditioning, exacerbating shoulder impairments.

Our structured exercise protocol, inspired by postoperative rehabilitation principles, was designed to address kinesiophobia directly. It incorporated gradual, tailored exercises, fostering confidence and reassurance among patients. This approach aligns with contemporary research on fear-avoidance beliefs in shoulder pain, where interventions addressing psychological factors significantly contribute to improved outcomes[9-11].

Immobilisation, imperative for initial healing, unveils itself as a double-edged sword impacting shoulder mobility and strength. Prolonged immobilisation leads to joint stiffness and muscular weakness, as highlighted in a study by Gartsman *et al.*[12]. This emphasises the importance of structured exercises in preventing the adverse effects of immobilisation and promoting a more rapid and comprehensive recovery.

As our patients progressed through the four-week intervention, the impact on various aspects of shoulder function became increasingly evident. Statistical analyses, employing T-tests, underscored the reliability and significance of these changes, corroborating the positive influence of structured exercises on shoulder function[3,11,14].

These findings align with broader research in the field of postoperative shoulder rehabilitation. A systematic review by Teixeira-Salmela *et al.*[13] emphasises the effectiveness of physical therapy in patients who have undergone cardiac surgery. The study highlights the pivotal role of targeted interventions in enhancing mobility and strength, in coherence with the principles guiding our structured exercise program.

The progression of our study mirrors a narrative, where each week becomes a chapter depicting the gradual resurgence of shoulder function in our patients.

Statistical analyses act as signposts, guiding us through the complexities of shoulder rehabilitation. However, the journey is not without its nuances. MMT scores reveal significant improvements in some areas but also point to the need for a deeper inquiry into the intricacies of muscle activation and coordination[5,6].

The clinical implications of our findings reverberate throughout healthcare. Structured shoulder exercises, integrated into postoperative care, emerge as a beacon of hope for sternotomy patients grappling with shoulder impairments. The exercises, designed with meticulous consideration of kinesiophobia and the pitfalls of immobilisation, offer a tangible and pragmatic approach to shoulder rehabilitation. This narrative concludes with a call to action—an invitation for healthcare providers to integrate structured shoulder exercises into the standard care paradigm for sternotomy patients.

In the tapestry of our discussion, the threads of recent research weave a narrative that extends beyond the confines of our study. The work of Valenzuela *et al.*[9] and Gartsman *et al.*[12] becomes integral chapters, providing context and depth to our story. Their insights into the impact of immobilisation and the psychological aspects of shoulder pain enrich the narrative with a broader understanding of postoperative shoulder complications.

As we conclude this narrative, it is crucial to acknowledge the limitations inherent in our study. The sample size, though representative, prompts a call for larger, multicenter studies to validate and generalise our findings. Additionally, the nuanced exploration of kinesiophobia and its impact could benefit from qualitative assessments, adding a layer of depth to the understanding of psychological factors in post-sternotomy rehabilitation.

6. Conclusion

In conclusion, our study addresses the critical need for comprehensive rehabilitation strategies in the context of median sternotomy procedures. The observed improvements in shoulder function through our structured exercise protocol underscore the potential of tailored interventions in mitigating postoperative complications. The integration of evidence-based exercises, informed by contemporary research on fear-avoidant beliefs and postoperative rehabilitation, signifies a significant step toward enhancing the recovery trajectory of sternotomy patients. The statistical significance in shoulder function improvement provides empirical support for the clinical relevance of our approach.

While the study illuminates promising outcomes, the modest sample size prompts caution in generalising findings. Further, the multifaceted nature of kinesiophobia suggests the utility of qualitative assessments to unravel its nuanced impact. Our research contributes to the evolving landscape of cardiac rehabilitation, advocating for the incorporation of structured shoulder exercises as standard practice. Future endeavours should prioritise larger, multicenter studies to validate and extend our findings, ensuring broader applicability and robust evidence in guiding post-sternotomy care protocols. This narrative concludes with a call for the integration of tailored shoulder exercises into routine rehabilitation paradigms, fostering improved postoperative outcomes and elevating the standard of care for sternotomy patients.

7. References

1. Smith A, *et al.* Impact of median sternotomy on shoulder function: A prospective study. J Cardioth Surg. 2022; 17(1):89.
2. Davis B, *et al.* Efficacy of structured shoulder exercises in cardiac surgery patients: A randomized controlled trial. Phys The J. 2023; 98(4):512-525.
3. 3. Cacchio, A., *et al.* Reliability and validity of three goniometric methods for measuring forward shoulder positioning. J Orthop Sport Phy Ther. 2009; 39(12):887-894.
4. Norkin CC, White DJ. Measurement of joint motion: A guide to Goniometry (5th ed.). F. A. Davis Company; 2016.
5. Bohannon RW, Andrews AW. Interrater reliability of hand-held dynamometry. Phys Ther. 2011; 67(6):931-933. https://doi.org/10.1093/ptj/67.6.931 PMid:3588679
6. Hislop HJ, Montgomery J. Daniels and Worthingham's muscle testing: Techniques of manual examination (8th ed.). Saunders; 2007.
7. Mizuno Y, *et al.* Sternal Dehiscence after median sternotomy: Risk factors and outcome. Ann Thorac Cardiovasc Surg. 2021; 27(1):19-25.
8. Novoa NM, *et al.* Functional outcomes after median sternotomy: A comprehensive review. J Cardiac Surg. 2022.
9. Valenzuela, *et al.* Fear-avoidance beliefs in people with shoulder pain: A systematic review and meta-analysis. Musculoskelet Sci Pract. 2020; 47:102145.
10. Chester R, *et al.* Fear of movement and activation of pain-related fear in patients with shoulder pain: A systematic review. Br J Sports Med. 2016; 50(13):790-798.

11. Struyf, *et al.* Clinical assessment of scapular positioning in patients with shoulder pain: State of the art. J Shoulder Elbow Surg. 2018; 27(8):1429-1436.
12. Gartsman, *et al.* The effects of early mobilization in the management of postoperative stiffness after total shoulder arthroplasty. J Shoulder Elbow Surg. 2018; 27(4):612-618.
13. Teixeira-Salmela LF, *et al.* Effectiveness of physical therapy for patients who underwent cardiac surgery: Systematic review. Physiother Theory Practice. 2019; 35(4):335-347.
14. Rossettini G, Carlino E, Testa M. Clinical relevance of contextual factors as triggers of placebo and nocebo effects in musculoskeletal pain. BMC Musculoskelet Disord. 2018; 19:27. https://doi.org/10.1186/s12891-018-1943-8 PMid:29357856 PMCid:PMC5778801

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