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EFFECT OF SCAR MOBILISATION TECHNIQUE ON CHEST EXPANSION AND BREATHING PATTERN IN CHILDREN FOLLOWING CHEST WALL SURGERY

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KEYWORDS

Scar mobilisation, chest expansion, pediatric physiotherapy, breathing pattern, chest wall surgery.

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Abstract

Background
Children undergoing chest wall surgery frequently develop postoperative scar adhesions that may restrict thoracic mobility and alter normal breathing mechanics. Reduced chest expansion and dysfunctional breathing patterns can negatively affect respiratory efficiency, physical activity, and overall recovery.

Aim
To evaluate the effectiveness of scar mobilisation techniques in improving chest expansion and restoring normal breathing patterns in children following chest wall surgery.

Methodology
A randomized experimental pretest–posttest study was conducted on 60 children aged 5–15 years who had undergone chest wall surgery. Participants were randomly allocated into a control group and a scar mobilisation group. Both groups received conventional postoperative physiotherapy, while the experimental group additionally received scar mobilisation techniques along with breathing retraining exercises for six weeks.

Results
Axillary chest expansion improved from 5.4 ± 1.3 cm to 6.8 ± 1.4 cm, nipple line expansion improved from 5.8 ± 1.4 cm to 7.2 ± 1.5 cm, and xiphisternal expansion improved from 6.3 ± 1.4 cm to 7.7 ± 1.5 cm. MARM scores improved from 4.1 ± 0.7 to 7.1 ± 0.7. All results were statistically significant ($p < 0.01$).

Conclusion
Scar mobilisation techniques combined with breathing retraining exercises were effective in improving chest expansion and restoring normal breathing patterns in children following chest wall surgery.

INTRODUCTION

Chest wall surgeries in children are commonly performed for congenital heart diseases, pulmonary malformations, thoracic deformities, tumors, traumatic injuries, and other cardiopulmonary conditions. Surgical procedures such as sternotomy, thoracotomy, rib resections, and corrective thoracic surgeries are often lifesaving and significantly improve survival rates and quality of life. However, despite advancements in surgical techniques and postoperative medical management, respiratory dysfunction and restricted chest wall mobility remain major postoperative concerns in pediatric patients.

One of the most commonly overlooked postoperative complications is the formation of scar tissue over the thoracic region. Scar tissue develops naturally during the wound healing process; however, in many cases the scar becomes thick, adherent, fibrotic, or nonpliable. Such changes may restrict the mobility of the skin, fascia, muscles, and underlying thoracic structures. In children, this problem is especially important because the thoracic cage and respiratory system are still developing.

Normal respiration depends on coordinated movement of the diaphragm, rib cage, intercostal muscles, abdominal wall, and accessory respiratory muscles. During inspiration, the diaphragm descends and the rib cage expands outward and upward, allowing efficient lung expansion. Restriction of thoracic structures due to postoperative scar adhesions may impair rib cage movement, reduce diaphragmatic excursion, and alter thoracoabdominal coordination.

Children with postoperative scar restrictions frequently develop shallow breathing patterns, increased use of accessory respiratory muscles, asymmetrical chest movement, reduced lung volumes, and decreased exercise tolerance. Postoperative pain and fear of movement further contribute to dysfunctional breathing patterns and protective postures. If not properly managed, these impairments may persist long after surgical healing and negatively affect physical development, participation in physical activities, posture, and overall quality of life.

Conventional postoperative physiotherapy generally focuses on breathing exercises, mobilization, postural correction, and prevention of pulmonary complications. However, targeted scar management is frequently neglected in routine rehabilitation protocols. Scar mobilisation techniques such as scar massage, skin gliding, cross-friction mobilisation, myofascial release, and scar stretching have been shown to improve scar pliability and tissue mobility in various clinical conditions.

These techniques may help restore chest wall compliance, improve thoracic expansion, enhance diaphragmatic breathing, and normalize respiratory mechanics. Scar mobilisation may also improve sensory feedback from the chest wall and reduce fear of movement and discomfort associated with scar tightness.

Several studies have highlighted the importance of thoracic mobility and respiratory rehabilitation following thoracic surgery. Tukanova et al. reported that thoracotomy commonly results in reduced chest wall movement and respiratory dysfunction. Courtney emphasized that thoracic mobility restrictions contribute to dysfunctional breathing patterns, while Cho et al. demonstrated that scar massage improves tissue pliability and reduces stiffness.

Despite growing awareness regarding scar management, limited research has specifically investigated the role of scar mobilisation techniques in pediatric patients following chest wall surgery. Most available literature focuses on adult populations or scar management in burn rehabilitation. Therefore, evidence regarding pediatric postoperative scar mobilisation remains limited.

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The present study was therefore conducted to evaluate the effectiveness of scar mobilisation techniques in improving chest expansion and restoring normal breathing patterns in children following chest wall surgery. The findings of the study may help support the inclusion of scar mobilisation as a routine component of postoperative pediatric physiotherapy rehabilitation.

MATERIALS AND METHODS

Study Design

Randomized experimental pretest–posttest control group design.

Sample Size

60 pediatric participants.

Groups

- Control Group (n = 30)
- Scar Mobilisation Group (n = 30)

Inclusion Criteria

- Children aged 5–15 years
- Healed postoperative chest wall scar
- Medically stable participants

Outcome Measures

1. Chest expansion measurement
2. Manual Assessment of Respiratory Motion (MARM)

Intervention

Both groups received conventional physiotherapy.

The experimental group additionally received:

- Scar massage
- Skin gliding
- Cross-friction mobilisation
- Myofascial release
- Breathing retraining exercises

Duration: 6 weeks, 5 sessions/week.

Statistical Analysis

Paired t-test and independent Student's t-test were used.

RESULTS

Table 1 Distribution of Age Group

Age	Number of Patients	Percentage
5-10	30	50%
10-15	25	41.6%
15-20	5	8.3%
Total	60	100

Out of 60 patients studied, 30(50%) had their age between 5-10years,25(41.6%) had age between 10-15years,5(8.3%) had age between 15-20years, Mean ± SD of age in the entire study group was 9.7 ± 3.3 years and minimum-maximum age range was 5-15 years.

Diagram 1 Showing the bar diagram distribution of age group

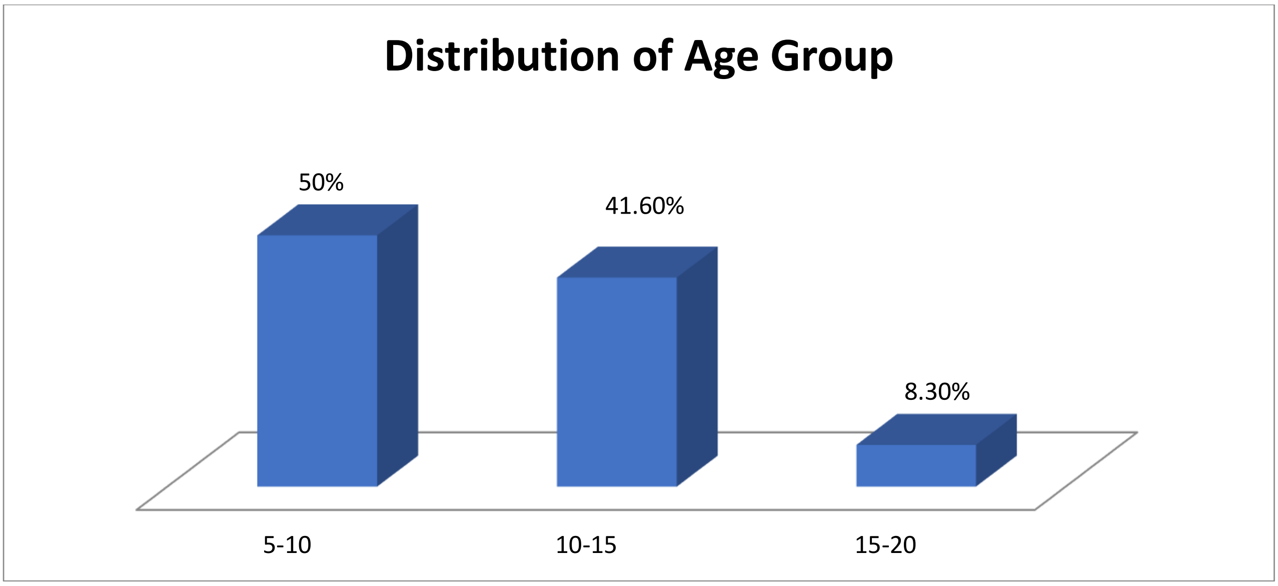

Table 2 Distribution of Gender

Gender	Number of Patients	Percentage
Male	34	56.6%
Female	26	43.4%
Total	60	100%

Out of 60 patients studied, 34(56.6%) had male, 26(43.4%) had female.

Diagram 2 Showing the Pie diagram distribution of gender

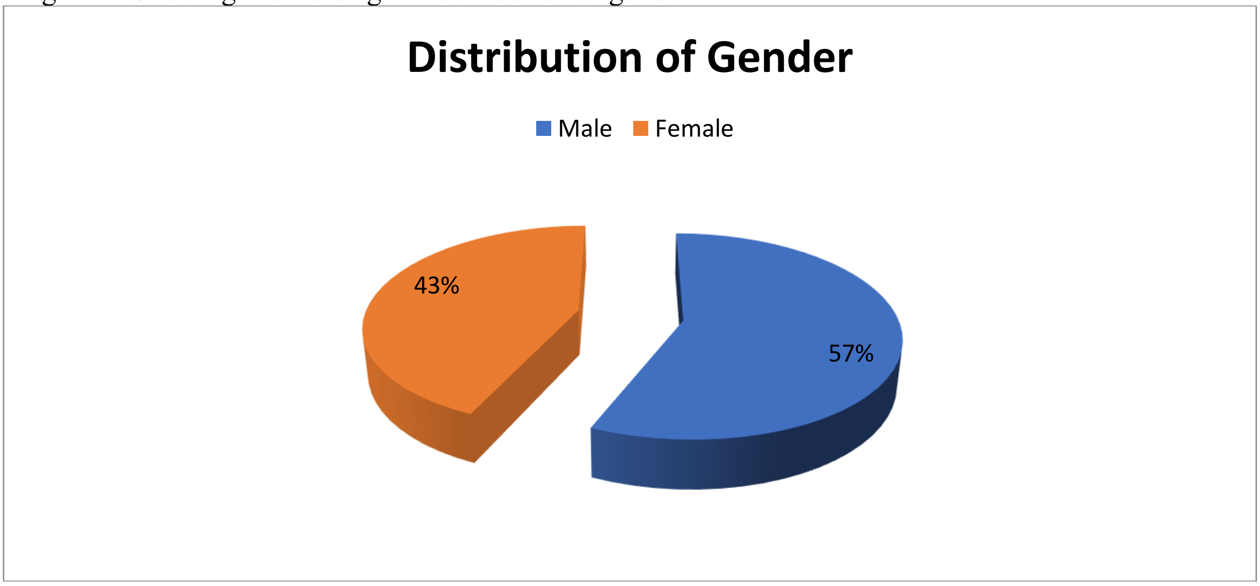

Table 3 Distribution of Area

Area	Number of Patients	Percentage

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Urban	40	66.6%
Rural	20	33.4%
Total	60	100%

Out of 60 patients studied, 40(66.6%) had urban, 20(33.4%) had rural.

Diagram 3 Showing the Pie diagram distribution of Area

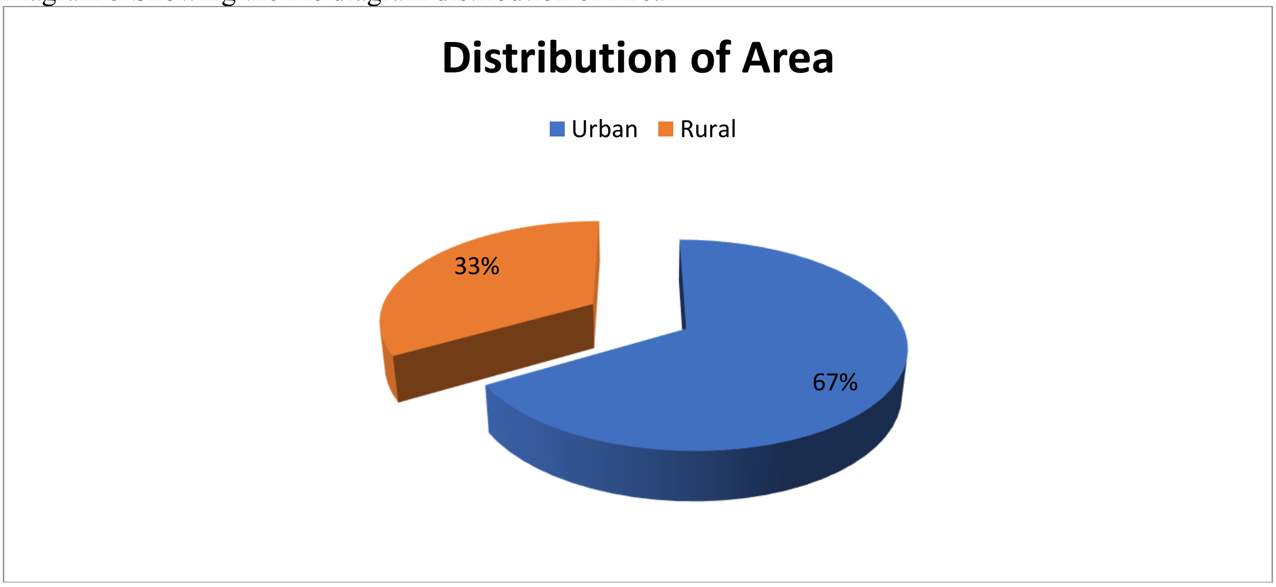

Table 4 Distribution of Base line Characteristic Pre and Post

	PRE	POST
Axillary Level	5.4 ± 1.3	6.8 ± 1.4
Nipple Line	5.8 ± 1.4	7.2 ± 1.5
Xiphisternal Level	6.3 ± 1.4	7.7 ± 1.5
MARM	4.1 ± 0.7	7.1 ± 0.7

All measured parameters (Axillary, Nipple Line, Xiphisternal Level, and MARM) show an increase from pre to post values, indicating overall improvement following the intervention.

Diagram 4 Showing the multiple bar diagram distribution of pre and post

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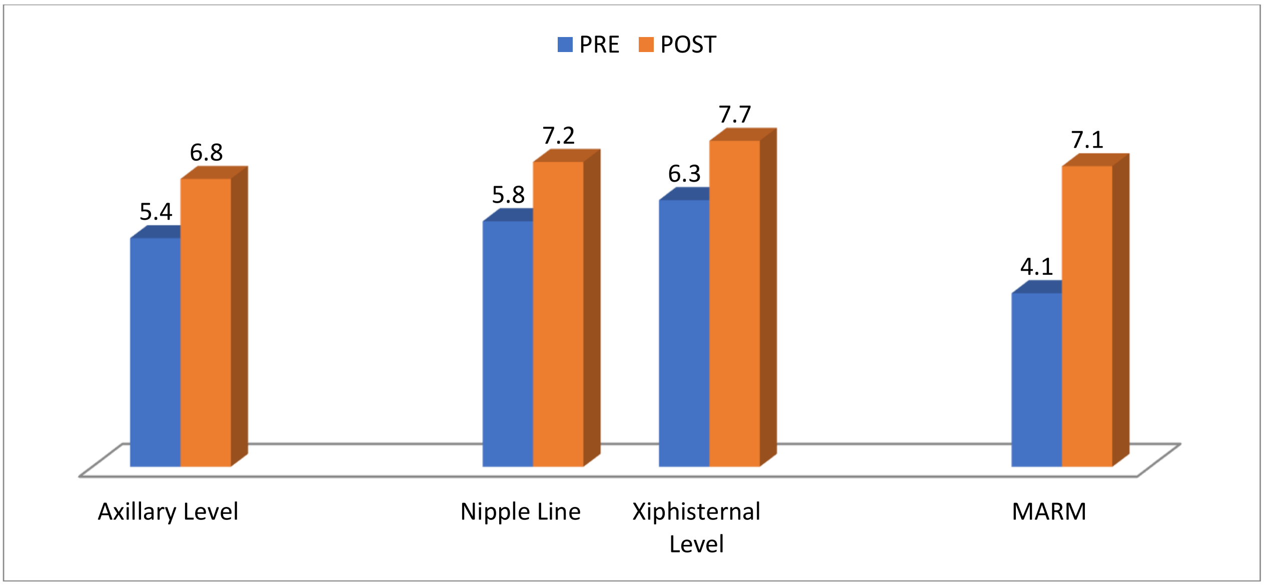

Table 5 Distribution of Axillary Level

Axillary Level	Mean ± SD (n=60)	Range	Maximum	Minimum
Axillary Pre	5.4 ± 1.3	4.6	7.9	3.3
Axillary Post	6.8 ± 1.4	5	9.4	4.4

The Axillary level increased from pre (5.4 ± 1.3; range 3.3–7.9) to post (6.8 ± 1.4; range 4.4–9.4)

Diagram 5 Showing the bar diagram distribution of Axillary Level

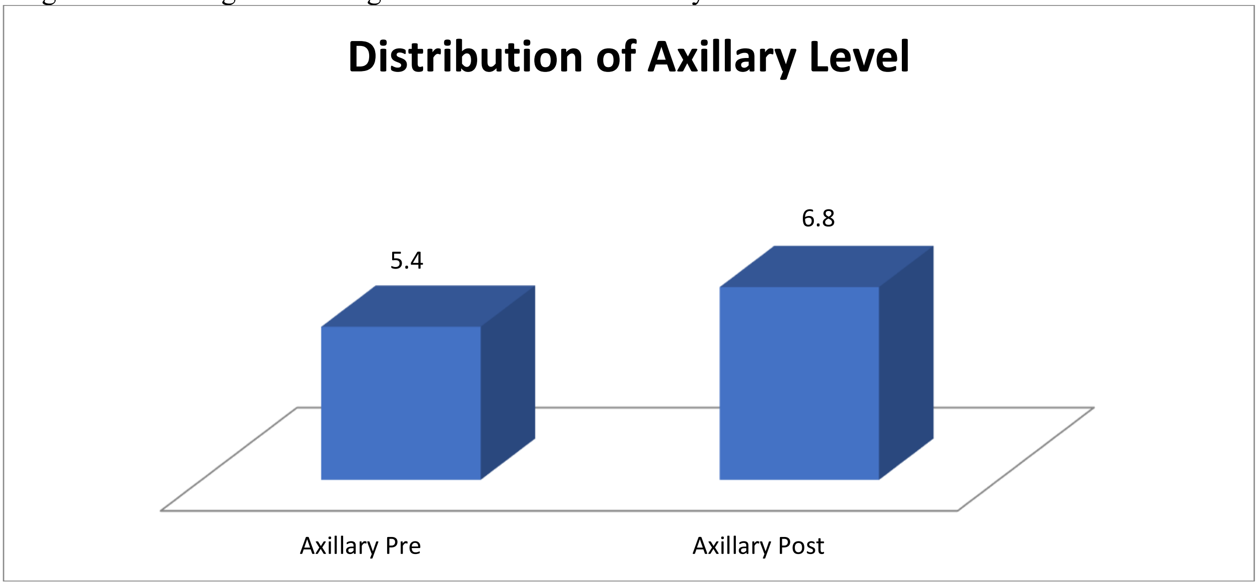

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Table 6 Distribution of Nipple Line

Nipple Line	Mean ± SD (n=60)	Range	Maximum	Minimum
Nipple Pre	5.8 ± 1.4	4.8	8.4	3.6
Nipple Post	7.2 ± 1.5	5.2	9.9	4.7

The Nipple Line values increased from pre (5.8 ± 1.4; range 3.6–8.4) to post (7.2 ± 1.5; range 4.7–9.9), indicating an overall improvement after the intervention.

Diagram 6 Showing the bar diagram distribution of Nipple Line

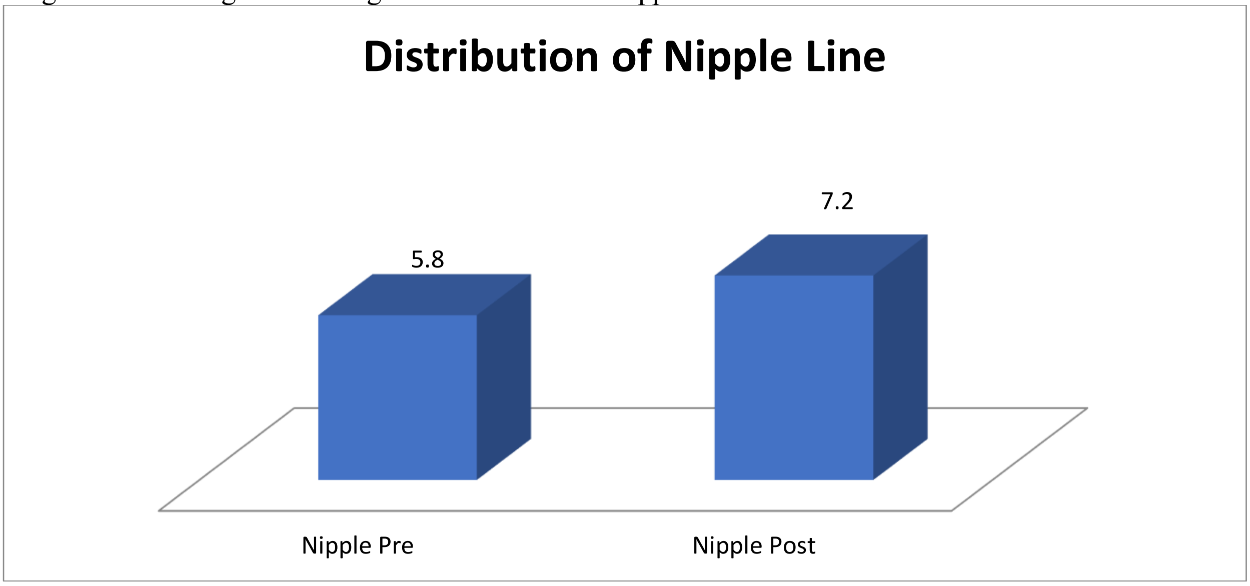

Table 7 Distribution of Xiphisternal Level

Xiphisternal Level	Mean ± SD (n=60)	Range	Maximum	Minimum
Xiphisternal Pre	6.3 ± 1.4	5	9	4
Xiphisternal Post	7.7 ± 1.5	5.4	10.5	5.1

The Xiphisternal level increased from pre (6.3 ± 1.4; range 4–9) to post (7.7 ± 1.5; range 5.1–10.5), indicating an overall improvement after the intervention.

Diagram 7 Showing the bar diagram distribution of Xiphisternal Level

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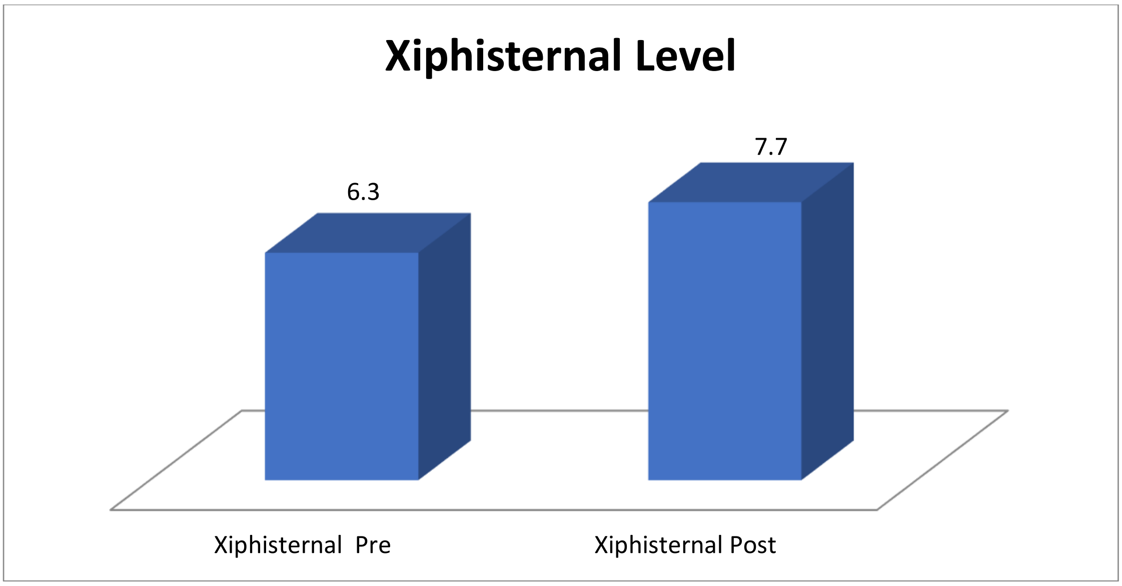

Table 8 Distribution of MARM Score

MARM	Mean ± SD (n=60)	Range	Maximum	Minimum
MARM Score (Pre)	4.1 ± 0.7	2	5	3
MARM Score (POST)	7.1 ± 0.7	2	8	6

The MARM scores show an increase from pre (4.1 ± 0.7; range 3–5) to post (7.1 ± 0.7; range 6–8), indicating an overall improvement in scores after the intervention.

Diagram 8 Showing the bar diagram distribution of MARM Score

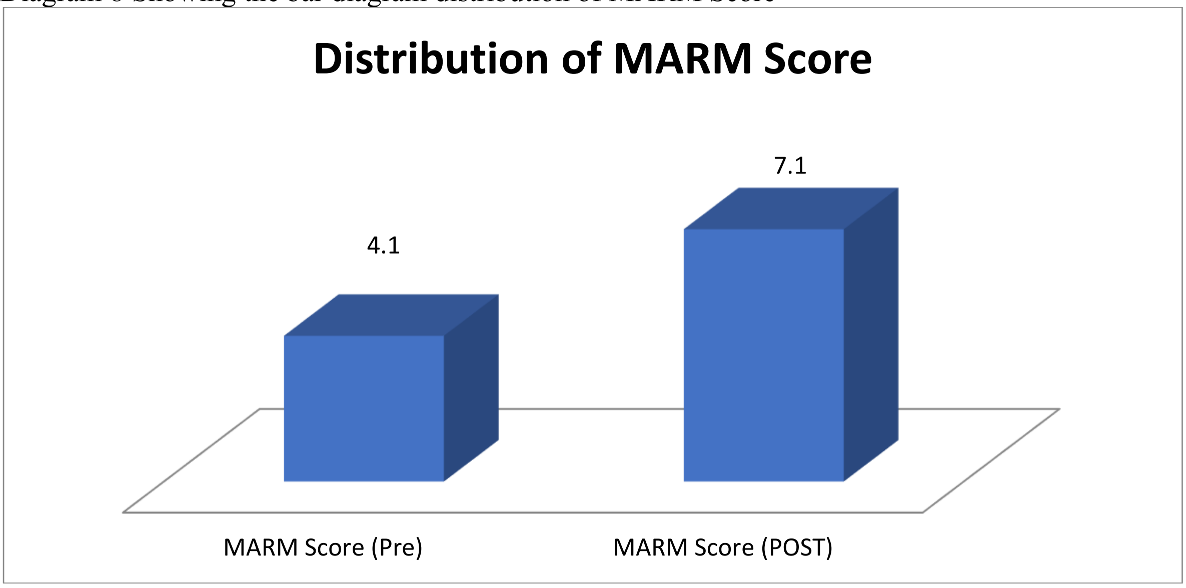

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Table 10 Comparison Axillary Level of Between and Within Pre and Post

Axillary Level	Mean ± SD (n=60)	Statistical Test Value
Axillary Pre	5.4 ± 1.3	t = 74.9,p = 0.0001,P<0.01(S)
Axillary Post	6.8 ± 1.4	

There is a highly significant increase in Axillary level from pre (5.4 ± 1.3) to post (6.8 ± 1.4) values ($t = 74.9$, $p < 0.01$)

Table 11 Comparison Nipple Line of Between and Within Pre and Post

Nipple Line	Mean ± SD (n=60)	Statistical Test Value
Nipple Pre	5.8 ± 1.4	t = 5.3,p = 0.0001,P<0.01(S)
Nipple Post	7.2 ± 1.5	

There is a highly significant increase in Nipple Line values from pre (5.8 ± 1.4) to post (7.2 ± 1.5) ($t = 5.3$, $p < 0.01$)

Table 12 Comparison Xiphisternal Level of Between and Within Pre and Post

Xiphisternal Level	Mean ± SD (n=60)	Statistical Test Value
Xiphisternal Pre	6.3 ± 1.4	t = 5.1,p = 0.0001,P<0.01(S)
Xiphisternal Post	7.7 ± 1.5	

There is a highly significant increase in Xiphisternal level from pre (6.3 ± 1.4) to post (7.7 ± 1.5) values ($t = 5.1$, $p < 0.01$)

Table 13 Comparison MARM of Between and Within Pre and Post

MARM	Mean ± SD (n=60)	Statistical Test Value
MARM Score (Pre)	4.1 ± 0.7	t = 22.2,p = 0.0001,P<0.01(S)
MARM Score (POST)	7.1 ± 0.7	

There is a highly significant increase in MARM scores from pre (4.1 ± 0.7) to post (7.1 ± 0.7) levels ($t = 22.2$, $p < 0.01$), indicating the intervention was effective.

RESULT INTERPRETATION

The findings of the present study demonstrated significant improvement in chest expansion and breathing patterns following scar mobilisation intervention in children after chest wall surgery.

Chest expansion measurements at the axillary, nipple line, and xiphisternal levels showed noticeable improvement after treatment, indicating enhanced thoracic mobility and better chest wall compliance. The increase in chest expansion suggests that scar mobilisation techniques helped reduce tissue adhesions and mechanical restrictions around the thoracic region.

Similarly, MARM scores improved significantly following intervention, reflecting restoration toward more normal breathing patterns. Participants demonstrated improved diaphragmatic breathing, better thoracoabdominal coordination, and reduced use of accessory respiratory muscles.

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The statistical analysis revealed that all measured variables showed highly significant improvement ($p < 0.01$), indicating that the intervention was effective in improving respiratory mechanics and functional breathing patterns in paediatric patients following chest wall surgery.

DISCUSSION

The present study was conducted to evaluate the effectiveness of scar mobilisation techniques in improving chest expansion and breathing patterns in pediatric patients following chest wall surgery. The findings demonstrated statistically significant improvement in chest expansion at the axillary, nipple line, and xiphisternal levels, along with significant improvement in breathing pattern assessment scores.

Chest wall surgery often results in scar formation and tissue adhesions that restrict normal thoracic mobility. Scar adhesions may limit the gliding of the skin, fascia, and muscles over the thoracic cage, thereby reducing chest wall compliance and impairing respiratory mechanics. Such restrictions can negatively affect diaphragmatic movement, thoracoabdominal coordination, and lung expansion.

In the present study, improvement in chest expansion values suggests that scar mobilisation techniques effectively reduced tissue restrictions and improved thoracic mobility. Increased chest wall mobility allows improved rib cage excursion and facilitates better lung expansion during inspiration.

The observed findings are consistent with previous studies emphasizing the importance of thoracic mobility in postoperative respiratory recovery. Tukanova et al. reported that thoracic surgical procedures commonly reduce chest wall movement and impair respiratory function. Similarly, Olsén et al. highlighted the importance of accurate chest expansion assessment as an indicator of thoracic mobility and respiratory efficiency.

The significant improvement in MARM scores observed in the present study indicates restoration toward more physiological breathing patterns. Prior to intervention, many participants demonstrated shallow breathing patterns and increased use of accessory respiratory muscles. Following intervention, breathing patterns became more diaphragmatic and coordinated.

This improvement may be explained by both mechanical and neurophysiological mechanisms associated with scar mobilisation. Mechanically, scar mobilisation helps break adhesions, improve tissue elasticity, restore fascial mobility, and increase thoracic compliance. Neurophysiologically, manual therapy techniques may improve sensory input from the chest wall, reduce pain and discomfort, decrease fear of movement, and improve motor control of respiration.

Bialosky et al. described that manual therapy produces both mechanical and neurophysiological effects that contribute to improved movement and functional performance. Similarly, Courtney emphasized that thoracic mobility restoration plays a critical role in correcting dysfunctional breathing patterns.

Another important aspect of the present study was the combination of scar mobilisation with breathing retraining exercises. While breathing exercises improve diaphragmatic activation and respiratory muscle coordination, scar mobilisation addresses the mechanical restrictions limiting thoracic movement. The combination of these interventions likely contributed to the significant improvements observed in respiratory function.

The findings of the present study are also supported by Karkouli et al., who reported that dysfunctional breathing in children can significantly affect physical and psychological wellbeing and that targeted breathing retraining may improve respiratory function.

Clinically, the results of the present study are highly relevant. Children undergoing chest wall surgery are at risk of long-term respiratory dysfunction if proper rehabilitation is not provided. Restricted chest expansion may contribute to decreased lung capacity, reduced exercise tolerance, poor posture, and decreased participation in physical activities.

The significant improvement observed in chest expansion and breathing pattern scores suggests that scar mobilisation techniques may help prevent long-term respiratory complications and improve functional recovery. The intervention is non-invasive, cost-effective, and feasible for integration into routine pediatric physiotherapy rehabilitation.

Overall, the findings of the study support the use of scar mobilisation techniques as an effective adjunct to postoperative physiotherapy management in children following chest wall surgery.

CONCLUSION

The findings of the present study showed that scar mobilisation techniques, when combined with breathing retraining exercises, helped improve chest expansion and breathing patterns in children who had undergone chest wall surgery. Children demonstrated better chest wall movement, improved breathing coordination, and reduced difficulty during breathing following the intervention.

Postoperative scar tightness and adhesions can restrict normal chest movement and negatively affect breathing efficiency. The results of this study suggest that scar mobilisation helps reduce these restrictions, allowing the chest wall to move more freely and supporting more natural diaphragmatic breathing.

The improvement observed in chest expansion and breathing pattern scores indicates that adding scar mobilisation to conventional physiotherapy may improve overall respiratory recovery and functional performance in pediatric patients after chest wall surgery.

Therefore, scar mobilisation techniques can be considered a safe, simple, and effective addition to postoperative pediatric physiotherapy rehabilitation programs. Early physiotherapy intervention focusing on scar mobility and breathing retraining may help children recover more comfortably, return to daily activities more confidently, and reduce the risk of long-term respiratory complications.

CLINICAL IMPLICATIONS

1. Scar mobilisation techniques may help improve thoracic mobility by reducing scar adhesions and increasing chest wall flexibility following surgery.
2. The intervention supports better diaphragmatic breathing and helps restore more normal breathing patterns in children.
3. Early scar management may reduce postoperative respiratory dysfunction, including shallow breathing and excessive use of accessory respiratory muscles.
4. Combining scar mobilisation with breathing retraining may improve overall functional recovery and participation in age-appropriate physical activities.
5. The technique is non-invasive, cost-effective, and easy to incorporate into routine pediatric physiotherapy rehabilitation programs.
6. Improved chest expansion and breathing efficiency may contribute to better endurance, confidence, and overall quality of life in children recovering from chest wall surgery.

LIMITATIONS

- The study was conducted on a relatively small sample size, which may limit the generalizability of the findings to a larger pediatric population.

- The duration of follow-up was short; therefore, long-term effects of scar mobilisation on respiratory function and chest wall mobility could not be evaluated.
- The study was conducted at a single center, which may limit the applicability of the findings across different clinical settings and populations.
- Advanced pulmonary function tests and imaging-based assessment tools were not included in the study.
- Variations in the type of surgery, scar location, and individual healing responses may have influenced the outcomes.
- Psychological factors such as fear of movement, pain perception, and emotional response to surgery were not assessed separately.

FUTURE RECOMMENDATIONS

1. Future studies should include a larger sample size to improve the generalizability and reliability of the findings.
2. Long-term follow-up studies are recommended to evaluate the sustained effects of scar mobilisation on chest expansion, breathing patterns, and functional recovery.
3. Multicenter studies involving different hospitals and rehabilitation settings may provide stronger clinical evidence and wider applicability of the results.
4. Future research may incorporate advanced pulmonary function tests and imaging-based assessment tools for more objective evaluation of respiratory function.
5. Comparative studies evaluating different scar mobilisation techniques and treatment durations may help identify the most effective rehabilitation protocol.
6. Further studies may investigate the combined effects of scar mobilisation with other physiotherapy interventions such as kinesiotaping, respiratory muscle training, and postural correction exercises.
7. Future research may also assess the psychological and quality-of-life outcomes associated with improved breathing and functional recovery in pediatric patients following chest wall surgery.

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