Journal of Physiotherapy Directories,

ISSN: 3107- 6939

Journal of Physiotherapy Directories (JPD)

Feasibility and Safety of Rhythmic Initiation-Based Neurophysiological Facilitation of Respiration Following Upper Abdominal Surgery: A Quasi-Experimental Study

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Vol 2, Issue 5: Page no. 236 - 243
Received: 6 Oct 2026, Accepted: 18 Oct 2026, Published: 1 Nov 2026

Abstract

Background: Upper abdominal surgery can alter respiratory mechanics during the early postoperative period because of pain, diaphragmatic dysfunction, reduced chest-wall movement, and altered thoraco-abdominal coordination. Manual facilitation techniques may provide tactile and proprioceptive assistance when patients have difficulty performing voluntary breathing exercises.

Objective: To evaluate the feasibility, safety, and immediate effects of rhythmic initiation-based neurophysiological facilitation (NPF) of respiration on pain, oxygen saturation, respiratory rate, and breathing pattern in patients following upper abdominal surgery.

Methods: A single-group, pre–post quasi-experimental study was conducted in 30 adults aged 18–60 years following upper abdominal surgery. Potential participants were screened from June 2024 to August 2025, and recruitment was conducted from July 2024 to August 2025. On postoperative day two, participants received one 60-minute session of rhythmic initiation-based NPF. Pain, oxygen saturation, respiratory rate, and breathing pattern were assessed immediately before and after the intervention. Safety and feasibility were assessed by documenting adverse events.

Results: Pain decreased from 4.12 ± 1.00 to 2.03 ± 0.65 (mean difference −2.09, 95% CI −2.43 to −1.75; Cohen's dz = −2.29; $p < 0.001$). Oxygen saturation increased from 94.67 ± 2.26% to 96.80 ± 1.73% (mean difference 2.13%, 95% CI 1.74–2.52; Cohen's dz = 2.05; $p < 0.001$). Respiratory rate increased from 21.70 ± 3.76 to 23.27 ± 2.05 breaths/min (mean difference 1.57 breaths/min, 95% CI 0.56–2.57; Cohen's dz = 0.58; $p = 0.003$). The distribution of recorded MARM breathing-pattern categories changed significantly (McNemar–Bowker test, $\chi^2 = 7.00$, df = 2, $p = 0.030$). Four participants (13.3%) reported mild, transient pain/discomfort; no serious adverse events were recorded.

Conclusion: A single session of rhythmic initiation-based NPF appeared feasible and well tolerated in this sample and was associated with immediate changes in pain, oxygen saturation, respiratory rate, and breathing-pattern distribution. Controlled studies are required to determine whether these changes are attributable to the intervention and whether they are sustained.

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Keywords: *Upper Abdominal Surgery, Rhythmic Initiation, Neurophysiological Facilitation, Breathing Pattern, Postoperative Physiotherapy.*

1. Introduction:

Upper abdominal surgery, including procedures performed above or near the umbilicus, can substantially alter respiratory mechanics during the early postoperative period. Because the surgical site is anatomically close to the diaphragm, patients may experience reduced diaphragmatic excursion, pain-related respiratory guarding, and restricted chest-wall expansion. These changes may contribute to rapid, shallow breathing and altered thoraco-abdominal movement after abdominal surgery. [1]

General anaesthesia may further reduce functional residual capacity and alter ventilation distribution, while postoperative pain and reduced mobility can contribute to transient respiratory muscle dysfunction and shallow breathing. [2] Conventional respiratory physiotherapy is commonly used during the postoperative period, but pain and limited tolerance may make voluntary breathing exercises difficult for some patients. [3]

Neurophysiological facilitation (NPF) of respiration refers in this study to manual facilitation of respiratory movement using tactile and proprioceptive input. Rhythmic initiation was operationally defined as a graded procedure in which the therapist initially guided the desired respiratory movement with manual contact and verbal cues and then progressed toward active participant participation and gentle resistance. The respiratory facilitation protocol used in the present study was adapted from a previously described chest-wall and diaphragm proprioceptive neuromuscular facilitation protocol.[4]

The Manual Assessment of Respiratory Motion (MARM) provides a clinical assessment of the distribution of respiratory movement between the upper rib cage, lower rib cage, and abdomen.[5] Previous studies have investigated respiratory facilitation techniques in mechanically ventilated or cardiothoracic populations.[4],[6] while postoperative respiratory physiotherapy has also been studied after upper abdominal surgery.[7] These populations and interventions do not directly answer whether a single session of rhythmic initiation-based NPF is feasible and well tolerated immediately after upper abdominal surgery.

The evidence gap is therefore not the general use of respiratory physiotherapy after surgery, but the limited evidence specifically describing immediate responses to a single session of rhythmic initiation-based NPF in patients recovering from upper abdominal surgery. A single-session design was selected to obtain preliminary information about immediate tolerability and short-term changes before undertaking a controlled trial with repeated treatment sessions and longer follow-up. The present study therefore aimed to evaluate the feasibility, safety, and immediate effects of rhythmic initiation-based NPF on pain, respiratory rate, oxygen saturation, and breathing pattern following upper abdominal surgery.

2. Material and Methodology:

Study design

This study was conducted as a single-group, pre–post quasi-experimental study. The study evaluated immediate within-participant changes following one intervention session.

Ethics approval

Ethical approval was obtained from the Institutional Ethics Committee of MGM Medical College and Hospital, Chh. Sambhajinagar, India (Approval No. MGM-ECRHS/2024/40).

Trial registration

The trial was prospectively registered with the Clinical Trials Registry–India (CTRI/2024/05/067318) before participant enrolment.

Sample size

Sample size was estimated using G*Power. Based on a two-tailed paired-samples test, an effect size (dz) of 0.55, $\alpha = 0.05$, and power $(1-\beta) = 0.80$, the required sample size was 28 participants. Thirty participants were recruited to allow for potential dropouts.

Participants and recruitment

Potential participants were screened for eligibility from June 2024 to August 2025. Participant recruitment was conducted from July 2024 to August 2025 in the general surgery ward of MGM Medical Hospital, Chh. Sambhajinagar, Maharashtra. Adults aged 18–60 years of either sex who had undergone upper abdominal surgery under general anaesthesia were eligible. For this study, upper abdominal surgery was defined as surgery involving structures in the upper abdominal region, including procedures involving the stomach, gallbladder, spleen, or upper abdominal bowel. For this study, eligibility was determined from the surgical-site information recorded during screening; participants whose procedure was recorded as lower abdominal surgery were excluded. Exclusion criteria were mechanical ventilation for more than 48 hours, haemodynamic instability, previous cardiac surgery, infected surgical wounds, chest-wall pain, rib or thoracic vertebral fractures, and chest-wall deformities. Mechanical ventilation for more than 48 hours was excluded to avoid inclusion of participants with prolonged ventilatory support and a substantially different postoperative respiratory course.

A total of 43 individuals were screened; 13 were excluded because they did not meet the inclusion criterion relating to the surgical site (lower abdominal surgery), and 30 participants were recruited and completed both pre- and post-intervention assessments.

Intervention

All participants received one session of rhythmic initiation-based NPF of respiration on postoperative day two. The intervention was delivered by a physiotherapist in the general surgery ward. The intervention comprised four 15-minute manual applications targeting the upper chest wall, lower lateral chest wall, sternum, and lower rib cage/diaphragm, giving a total duration of approximately 60 minutes. Direct pressure over the surgical incision was avoided, and manual contact was adjusted according to participant tolerance.

During rhythmic initiation, respiratory movement was initially guided manually with verbal cues. The therapist then progressed the participant toward active participation and gentle resistance during the relevant phase of respiration. The specific manual applications followed the protocol adapted from Zwoliński et al.[4]

Outcome measures

Pain

Pain intensity was assessed using a 0–10 Visual Analogue Scale (VAS) immediately before and immediately after the intervention. The original study data record the pre- and post-intervention VAS values, but the specific assessment condition (e.g., rest, deep breathing, or coughing) was not recorded.[8]

Oxygen saturation and respiratory rate

Oxygen saturation was measured using a pulse oximeter. Respiratory rate was assessed by observing respiratory/chest-wall movement over one minute. The assessor was not blinded to the intervention.

Breathing pattern

Breathing pattern was assessed using the Manual Assessment of Respiratory Motion (MARM). The assessment includes six conditions: sitting naturally and breathing normally, sitting slumped, sitting upright, taking a deep slow breath, breathing sideways into the examiner's hands, and returning to natural breathing. Each condition is scored from 0 to 3, where 0 represents balanced movement, 1 mild thoracic predominance, 2 moderate thoracic predominance, and 3 strong thoracic predominance, giving a possible total score of 0–18.[5] In the present dataset, the breathing-pattern category recorded on the original assessment sheet was retained for analysis as balanced, mild thoracic, or moderate thoracic.

Numerical total MARM scores were not retained; therefore, no post-hoc total-score cut-offs were imposed.

Safety and feasibility

Participants were monitored throughout the intervention for pain, discomfort, respiratory distress, oxygen desaturation, and hemodynamic instability. The intervention was modified or discontinued if clinically significant intolerance occurred. We documented adverse events occurring during or immediately after the intervention.

Statistical analysis

Analyses were performed using SPSS version 26.0. Continuous variables were summarised using mean ± standard deviation and categorical variables using frequencies and percentages. The distribution of within-participant differences was assessed using the Shapiro–Wilk test before paired comparisons. Pre- and post-intervention continuous outcomes were compared using paired t-tests. Mean within-participant differences and 95% confidence intervals (CIs) were reported. For paired comparisons, effect size was expressed as Cohen's dz, calculated as the mean paired difference divided by the standard deviation of the paired differences. The categorical distribution of recorded breathing-pattern classifications was analysed using the McNemar–Bowker test of symmetry. A two-sided p-value < 0.05 was considered statistically significant. Because multiple outcomes were evaluated, p-values were interpreted as evidence of within-sample change rather than as confirmatory evidence of efficacy.

Results:

Forty-three individuals were screened for eligibility between June 2024 and August 2025. Thirteen were excluded because they had lower abdominal surgery. Thirty participants were recruited from July 2024 to August 2025 and completed both pre- and post-intervention assessments.

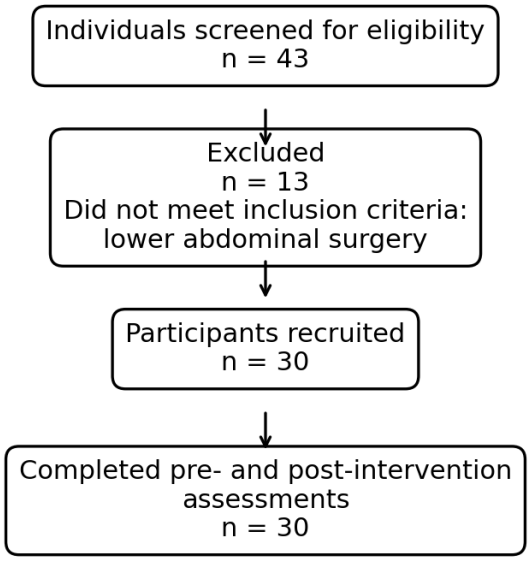


Figure 1. Participant flow.

Baseline characteristics

Characteristic	n	%
Male	19	63.3
Female	11	36.7

Table 1. Baseline demographic characteristics (N = 30).

The mean age of participants was 42.5 ± 16.3 years. Nineteen participants (63.3%) were male and 11 (36.7%) were female.

Adverse events

Adverse event	n (%)
No adverse event	26 (86.7%)
Mild transient pain/discomfort	4 (13.3%)

Table 2. Adverse events during or immediately after the intervention.

Immediate changes in pain, oxygen saturation and respiratory rate

Outcome	Pre, mean ± SD	Post, mean ± SD	Mean difference (95% CI)	Cohen's dz	p-value
Pain (VAS)	4.12 ± 1.00	2.03 ± 0.65	−2.09 (−2.43 to −1.75)	−2.29	<0.001
SpO_2 (%)	94.67 ± 2.26	96.80 ± 1.73	2.13 (1.74 to 2.52)	2.05	<0.001
Respiratory rate (breaths/min)	21.70 ± 3.76	23.27 ± 2.05	1.57 (0.56 to 2.57)	0.58	0.003

Table 3. Immediate changes in continuous outcomes after rhythmic initiation-based NPF (N = 30). Pain intensity decreased from 4.12 ± 1.00 before the intervention to 2.03 ± 0.65 after the intervention. Oxygen saturation increased from 94.67 ± 2.26% to 96.80 ± 1.73%. Respiratory rate increased from 21.70 ± 3.76 to 23.27 ± 2.05 breaths/min. All three within-participant changes were statistically significant.

Changes in breathing-pattern distribution

Baseline	Post: Balanced	Post: Mild thoracic	Post: Moderate thoracic	Total
Balanced	16	0	0	16
Mild thoracic	3	5	0	8
Moderate thoracic	0	4	2	6
Total	19	9	2	30

Table 4. Cross-tabulation of recorded MARM breathing-pattern categories before and after intervention. The number of participants recorded as having a balanced breathing pattern increased from 16 at baseline to 19 after the intervention. Among the eight participants with a mild thoracic pattern at baseline, three shifted to a balanced pattern and five remained mildly thoracic. Among the six participants with a moderate thoracic pattern at baseline, four shifted to a mild thoracic pattern and two remained moderately thoracic. The McNemar–Bowker test indicated a statistically significant change in the distribution of breathing-pattern categories ($\chi^2 = 7.00$, df = 2, $p = 0.030$). Because 16 participants were already classified as having a balanced breathing pattern at baseline, a potential ceiling effect should be considered.

5. Discussion:

This single-group quasi-experimental study evaluated the feasibility, safety, and immediate within-participant changes associated with one session of rhythmic initiation-based NPF after upper abdominal surgery. Four participants (13.3%) reported mild, transient pain or discomfort, and no serious adverse events, respiratory distress, oxygen desaturation, or hemodynamic instability were documented. These findings support the feasibility and short-term tolerability of the intervention in the studied setting, but the single-group design does not permit attribution of changes solely to NPF.

Pain decreased significantly immediately after the intervention. The finding is consistent with the possibility that manual facilitation and guided respiratory movement may alter the experience of discomfort associated with breathing. Postoperative physiotherapy is commonly used to address respiratory consequences after upper abdominal surgery, although the specific contribution of NPF

cannot be determined from the present design.[9],[10] However, the study did not assess a specific pain condition such as pain during deep breathing or coughing, and analgesic administration was not controlled as part of the intervention. The magnitude of the immediate change should therefore be interpreted as a within-session change rather than proof of a clinically meaningful treatment effect.

Oxygen saturation increased immediately after the intervention. Enhanced chest-wall movement and more coordinated respiratory motion are plausible explanations, but diaphragmatic excursion, tidal volume, minute ventilation, and ventilation–perfusion matching were not directly measured. Postoperative respiratory physiotherapy and breathing exercises have been investigated for their effects on respiratory function and thoraco-abdominal movement, but the present study cannot determine whether the observed change was specifically attributable to NPF. [6],[11] the observed change may also reflect spontaneous short-term variation or concurrent postoperative care.

Respiratory rate increased from 21.70 ± 3.76 to 23.27 ± 2.05 breaths/min. This increase occurred alongside an increase in oxygen saturation and without documented respiratory distress. However, because tidal volume and minute ventilation were not measured, it cannot be concluded that the increase represented improved ventilation. It may also reflect a compensatory or transient physiological response.

The recorded MARM categories shifted toward greater representation of balanced breathing. Three participants moved from mild thoracic to balanced, and four moved from moderate thoracic to mild thoracic. Similar postoperative breathing-exercise research has examined changes in breathing pattern and thoraco-abdominal motion.[11] The present finding is compatible with an immediate change in the distribution of respiratory movement, but interpretation should be cautious because the analysis used categorical observations rather than retained numerical MARM totals, and 16 participants were already balanced at baseline. The ceiling effect may have limited the ability to detect improvement in these participants.

The rationale for assessing an immediate, single-session response was feasibility and preliminary safety. Establishing whether a manual respiratory facilitation procedure can be delivered without important intolerance and whether measurable short-term changes occur provides preliminary information for designing controlled trials. Postoperative physiotherapy practice and management vary across settings, supporting the need for a clearly defined intervention and controlled evaluation in future studies.[9],[10] Future trials should include a comparator group, standardise analgesic and concurrent respiratory physiotherapy exposure, use blinded outcome assessment where feasible, and evaluate repeated sessions and longer-term outcomes.

Limitations

The single-group pre–post design limits causal inference because spontaneous postoperative recovery, analgesic effects, and concurrent medical or physiotherapy care could have contributed to the observed changes.

The sample size was small and drawn from a single centre, limiting generalisability.

Only immediate post-intervention outcomes were assessed; persistence of the observed changes and effects on postoperative pulmonary complications were not evaluated.

Respiratory rate was assessed by observation by an unblinded therapist, which may introduce measurement bias.

The numerical MARM total scores were not retained in the available dataset; therefore, categorical breathing-pattern analysis was used and no numerical-score cut-offs were retrospectively imposed.

Sixteen participants had a balanced breathing pattern at baseline, creating a potential ceiling effect for the categorical breathing-pattern outcome.

The VAS assessment condition (e.g., rest, deep breathing, or coughing) was not recorded in the available study data, limiting interpretation of the pain outcome.

Tidal volume, minute ventilation, spirometry, and diaphragmatic excursion were not measured.

Surgical-procedure and incision frequencies were not reported in the revised baseline table because the available patient-level spreadsheet contained inconsistent procedure labels and did not permit reliable reconciliation of the original procedure counts.

Future research

Future studies should use randomised controlled designs with larger samples and a comparator group. Pain should be assessed under prespecified conditions, such as at rest and during a standardised

respiratory manoeuvre, with analgesic exposure documented. Blinded or independent assessment of respiratory rate and breathing pattern should be considered. Numerical MARM scores should be retained alongside any categorical interpretation. Objective respiratory outcomes, including spirometry, respiratory inductive plethysmography, or diaphragmatic ultrasonography, and longer-term outcomes should be evaluated. Repeated-session protocols should be investigated to determine whether immediate changes are sustained.

6. Conclusion:

A single 60-minute session of rhythmic initiation-based neurophysiological facilitation appeared feasible and well tolerated in adults during the early postoperative period following upper abdominal surgery. Immediate within-participant changes were observed in pain, oxygen saturation, respiratory rate, and the distribution of recorded breathing-pattern categories. Because the study had no control group and assessed only immediate outcomes, these findings should be considered preliminary and should not be interpreted as evidence of comparative treatment efficacy.

Declarations

Conflict of interest
The authors declare no conflicts of interest.
Funding
No external funding was received for this study.
Data availability
The data supporting the findings of this study are available from the corresponding author upon reasonable request.
Author contributions
Vrunda V. Charkha: Conceptualization, intervention administration, data collection, data analysis, and manuscript drafting.
Vaibhav M. Kapre: Study design guidance, methodological supervision, data interpretation, and critical revision of the manuscript.

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