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Effectiveness of respiratory exercises and abdominal strength training on pain, abdominal strength, and quality of life in patients following abdominal surgery: A randomized controlled trial

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Abstract

BACKGROUND: Abdominal surgery is a common procedure for treating infections, obstructions, tumors, or inflammatory bowel disease. Postoperative complications can include pain, muscle weakness, incisional hernias, and reduced quality of life (QOL). This study assessed the effects of respiratory exercises and abdominal strength training on pain and QOL in 183 patients (aged 18–65) after open abdominal surgery.

MATERIALS AND METHODS: Patients were divided into two groups: one received respiratory exercises plus abdominal strength training, while the other did only respiratory exercises (3×/week for 4 weeks). Pain (visual analog scale), abdominal strength (pressure biofeedback), and QOL (WHOQOL) were measured at baseline, 15 days, and one month post-surgery.

RESULTS: Results showed significant within-group improvements in pain, strength, and QOL ($P < 0.001$). However, between-group comparisons found no significant differences in pain or QOL ($P > 0.05$), except for greater abdominal strength improvement in the intervention group ($P < 0.001$).

CONCLUSION: Combining respiratory exercises with abdominal strength training enhances muscle recovery post-surgery but does not significantly reduce pain compared to respiratory exercises alone. Integrating these exercises into rehabilitation may improve strength and overall recovery.

Keywords:

Abdominal surgery, muscle strength, pain, postoperative rehabilitation

Introduction

Advancements in healthcare are contributing to a rapidly growing population in the current era. With a growing population, maintaining a high quality of life (QOL) presents a significant challenge. Additionally, a gradual decrease in physical activity, combined with major life events such as hospitalization and surgery, can further weaken their functional abilities and daily living skills.[1] While modern medical innovations can help mitigate this loss of adaptive capacity, physical exercise training and sustained activity during such events may further reduce or even prevent these declines.[2]

The majority of the population undergoes various surgical procedures at some point in their lives due to underlying medical conditions. Surgery has become essential for improving patients' QOL within the healthcare system. According to a 2022 World Bank report, approximately 234 million operations are performed each year,

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and around 164 million disability-adjusted life years are attributed to surgical conditions, representing 11% of the total disease burden.[3]

Postoperative pain, reduced abdominal strength, and reduced QOL are common challenges following abdominal surgery, often leading to prolonged recovery, decreased mobility, and increased healthcare burdens. It often results from impaired respiratory function, weakened abdominal muscles, and prolonged immobilization.[4,5] Despite advances in surgical techniques and pain management, many patients continue to experience significant discomfort and functional limitations postoperatively. Respiratory dysfunction and weakened abdominal muscles further exacerbate these issues, contributing to complications such as atelectasis, pneumonia, and delayed wound healing.

Effective postoperative rehabilitation strategies are essential to minimize complications, enhance recovery, and improve patient outcomes. Respiratory exercises, such as diaphragmatic breathing and incentive spirometry, have been shown to improve lung function and reduce pulmonary complications, while abdominal strength training can help restore core stability and functional capacity.[6] Emerging evidence supports the role of postoperative exercise in improving recovery following thoracic, abdominal, and major joint replacement surgeries, particularly in high-risk patients.[7,8] In line with fast-track and enhanced recovery after surgery protocols, early postoperative mobilization and targeted exercises are recommended to accelerate rehabilitation and minimize complications.

Despite these advancements, the specific effects of structured breathing exercises and abdominal strength training in patients recovering from open abdominal surgery remain underexplored. While respiratory exercises are commonly prescribed to prevent pulmonary complications, their combined application with progressive abdominal strengthening has not been sufficiently studied in this population. Furthermore, objective assessment of abdominal muscle strength and its correlation with postoperative pain, abdominal strength, and QOL is lacking in current literature.

This randomized controlled trial (RCT) aims to evaluate the effectiveness of a tailored program combining respiratory exercises and progressive abdominal strength training in alleviating pain, improving abdominal strength, and enhancing QOL among patients recovering from abdominal surgery. By comparing this intervention with standard postoperative care, we seek to provide evidence-based recommendations for optimizing recovery and improving long-term patient well-being.

Materials and Methods

Before the actual commencement of the study, ethical clearance was taken from the institutional ethical committee, Faculty of Medicine, Parul University Human Research (PU-IECHR), Vadodara (Approval vide, PU-IECHR/PIMSR/00/081734/2601). CTRI registration was done in Clinical Trial Registry, India (Reg. No.: CTRI/2020/09/027868 [Registered on: 17/09/2020]). Sample size calculation was done by using the prevalence of surgical procedures (15.8%) by using the formula $S = z^2Pq/L^2$. Calculated sample size was 193. Figure 1 shows the participant's recruitment procedure. By using a convenient sampling method total of 190 patients were included in the study. The prior no objection certificate was taken from the different hospitals, from where the data has been collected.

The study included postoperative patients aged 18 to 65 who had undergone open abdominal surgery and were referred for physiotherapy. Participants with known neurological deficits, unstable cardio-respiratory disease, hemodynamically unstable, and other unstable medical conditions were excluded from the study. Although the study focused on postoperative abdominal surgical patients, the most common surgical procedures performed included open abdominal surgeries that were performed under general anesthesia and involved an incision into the abdominal cavity, along with visceral manipulation. Patients were required to have a minimum overnight stay for monitoring in an acute care facility. The procedures utilized open or minimally invasive techniques, with total incision lengths of 5 cm or more. These surgeries were classified as either upper abdominal surgery (extending above the umbilicus) or lower abdominal surgery (below the umbilicus). With prior informed consent obtained from all participants and/or their relatives, participants were randomly assigned to one of two groups (Group A or Group B) using a chit-picking method to ensure unbiased allocation. An equal number of chits, labeled "Group A" or "Group B" according to a predetermined allocation ratio (e.g., 1:1), were used. The study procedure was clearly explained to all participants.

Before inclusion in the study, each patient was comprehensively assessed for various factors. On the first day, evaluations were conducted to measure pain, abdominal strength, and QOL. To ensure objectivity and avoid bias, assessor blinding was implemented, meaning the assessor was unaware of the group assignments. Pain was measured using a Visual analog scale (VAS),[9-11] abdominal strength was measured through Chattanooga pressure biofeedback,[12] whereas QOL was assessed using the World Health Organization QOL (WHOQOL),[13,14] Gujarati version. VAS and abdominal

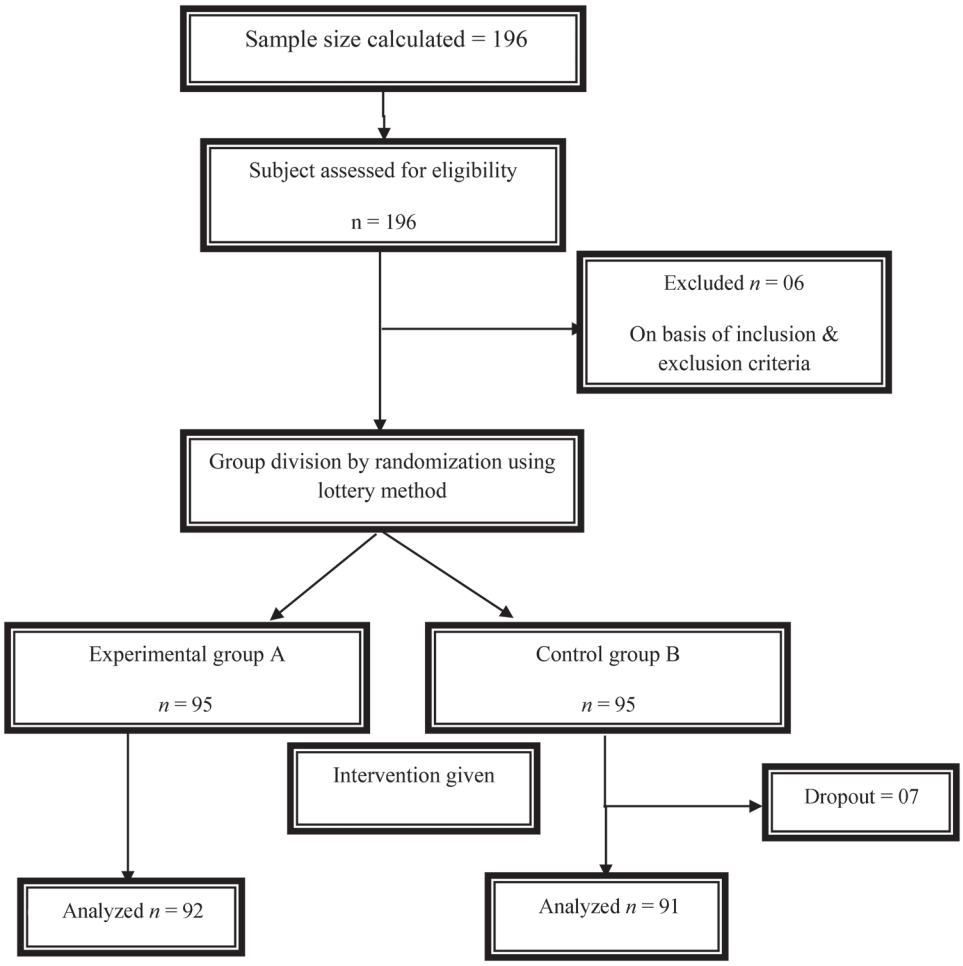

Figure 1: Flow diagram

strength were recorded on the first day of operation within 24 h (Base), 15th day, and again after one month, and WHOQOL was recorded on the first day and after one month.

Patients in Group A participated in respiratory exercises combined with abdominal strength training three times a week for four weeks. Group B received only respiratory exercises three times a week for the same duration. The respiratory exercises included deep breathing, huffing, and coughing techniques, while abdominal strength training comprised pelvic tilting, knee rolling, buttock lifts, and head lifts. Since the patients underwent various types of abdominal surgeries, their hospital stays varied from one day to one month, depending on their vital stability. This treatment protocol was adhered to during their time in the hospital. After discharge, the same treatment protocol continued at the patients' residences at their convenience. A total of 190 patients were included in the study. Seven patients were not able to complete the protocol due to their personal limitations. In total, 183 patients were re-evaluated at predetermined intervals postoperatively using the same outcome measures.

Statistical Analysis and Results

All statistical analyses were conducted using SPSS™ version 20.0. Subjects were assessed at baseline before treatment, 15th day, and at the end of one month. Before the final analysis, the data was screened for transcription errors, normality assumptions, and homogeneity of variance, which are prerequisites for parametric calculations in the analysis of differences and related measures. The Kolmogorov–Smirnov test was done for baseline comparison. The data was tested using Mauchley's test of sphericity and was found to have a level of significance <0.001 for all outcomes with Huynh–Feldt epsilon values >0.75. Therefore, one-way repeated measure ANOVA for within-group comparison of VAS was used. The Wilcoxon signed rank test was used for comparison of within-group QOL pre- and post-measures. For between-groups comparison of measures, repeated measures multivariate ANOVA was used at each follow-up period. The alpha level was set at 0.05 to control for type I error, and the confidence interval was set at 95% for all statistical analyses.

The study includes 183 participants, with a mean and SD for the intervention group 45.69 ± 13.01 (n = 92) and for the control group 39.06 ± 12.27 (n = 91), and Table 1 shows descriptive statistics of participants.

As shown in Table 2, baseline comparison of both groups indicates that the data was not normally distributed.

Table 3 shows the within-group analysis of VAS and abdominal strength in the intervention group and control group at baseline, 15 days, and at one month [Figures 2 and 3]. In both groups, pain has reduced from baseline to one month. It proves that respiratory exercises, as well as abdominal strength training, are effective in reducing pain in postoperative abdominal surgeries.

Table 1: Demographic distribution of subjects

Characteristics	Intervention group (n = 92)		Control group (n = 91)	
	n	%	*n*	%
Age (years)				
18–35	92	50.27	91	49.72
Gender				
Male	42	45.65	53	58.24
Female	50	54.35	38	41.76

Table 2: Baseline comparison of both the groups

Outcome measures	Intervention group (n = 92) Mean ± SD	Control group (n = 91) Mean ± SD	*T* value	*P* value
VAS base	5.21 ± 1.31	4.84 ± 2.18	1.524	0.131
Strength base	3.66 ± 1.73	5.08 ± 1.36	5.737	0.073
QOL-D1	41.46 ± 9.49	42.46 ± 10.08	0.743	0.459
QOL-D2	42.68 ± 12.83	44.32 ± 11.97	1.093	0.277
QOL-D3	37.21 ± 12.06	40.07 ± 14.36	1.650	0.102
QOL-D4	44.45 ± 7.98	46.06 ± 9.14	1.297	0.198

For t test at level of significance $P < 0.05$
QOL = Quality of life, VAS = visual analog scale

Table 3: Within-group analysis of visual analog scale (VAS) and abdominal strength for both the groups

Group	VAS		Mean difference	*P* value
Intervention group	VAS base	VAS-15 days	2.141*	0.00
		VAS-30 days	4.783*	0.00
	Vas-15 days	VAS base	–2.141*	0.00
		VAS-30 days	2.641*	0.00
	VAS-30 days	VAS base	–4.783*	0.00
		VAS-15 days	–2.641*	0.00
Control group	VAS base	VAS-15 days	2.176*	0.00
		VAS-30 days	4.066*	0.00
	VAS-15 days	VAS base	–2.176*	0.00
		VAS-30 days	1.890*	0.00
	VAS-30 days	VAS base	–4.066*	0.00
		VAS-15 days	–1.890*	0.00
Group	**Abdominal muscle strength**		**Mean difference**	***P* value**
Intervention group	Base	15 days	–2.478*	0.00
		30 days	–5.435*	0.00
	15 days	Base	2.478*	0.00
		30 days	–2.957*	0.00
	30 days	Base	5.435*	0.00
		15 days	2.957*	0.00
Control group	Base	15 days	–1.692*	0.00
		30 days	–3.934*	0.00
	15 days	Base	1.692*	0.00
		30 days	–2.242*	0.00
	30 days	Base	3.934*	0.00
		15 days	2.242*	0.00

Based on estimated marginal means; The mean difference is significant at the $P < 0.05$ level; Adjustment for multiple comparisons: Bonferroni
VAS = Visual analog scale;* test result is significant at 0.05 level

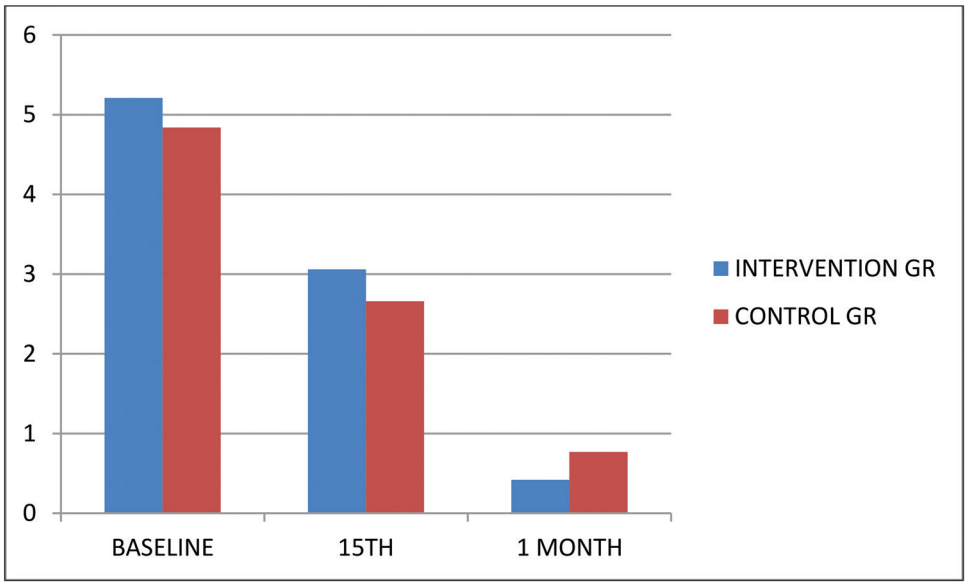

Figure 2: Within-group analysis of the visual analog scale

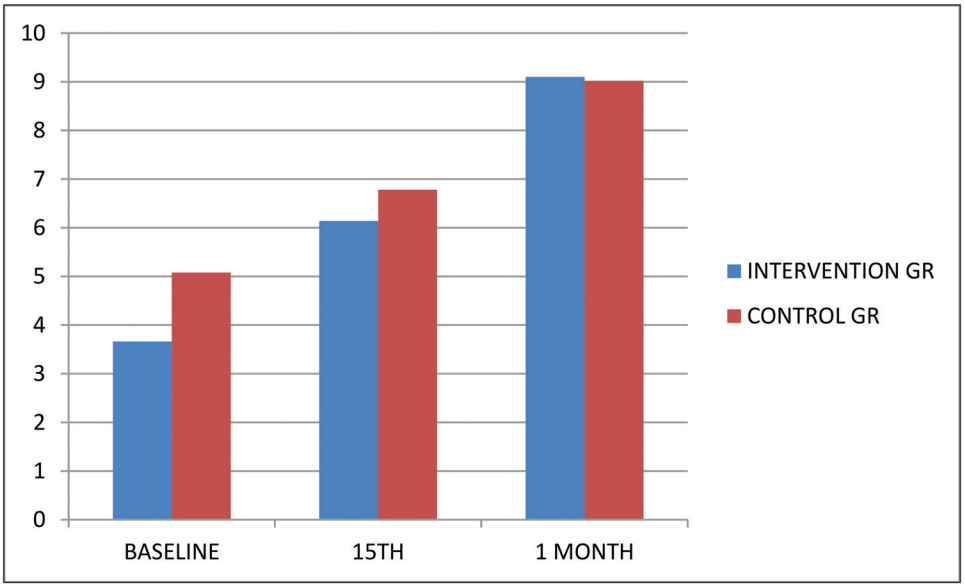

Figure 3: Within-group analysis of abdominal strength

Table 4 shows the within-group analysis of QOL in the intervention group and control group at baseline, and at one-month period for all four domains of QOL. In both groups, QOL has improved from baseline to one month [Figure 4]. It proves that respiratory exercises as well as abdominal strength training are effective in improving QOL in postoperative abdominal surgeries.

Between-Group Analysis shows that the results for experimental and control groups were not different statistically in terms of VAS and QOL domain-wise, as suggested by P value > 0.05 for all. It proves that respiratory exercises as well as abdominal strength training are not effective in reducing pain and improving QOL in postoperative abdominal surgeries [Table 5].

Discussion

The RCT aimed to assess the effectiveness of respiratory exercises and an abdominal strength training program on pain, abdominal strength, and QOL in patients recovering from abdominal surgeries. The study's findings indicate that both respiratory exercises alone and the combination of respiratory and abdominal strength training significantly enhance abdominal strength and activities of daily living (ADL), while also reducing postoperative pain. When comparing the two groups, both showed improvements in abdominal muscle strength at both assessment intervals; however, the experimental group, which received additional abdominal strengthening, demonstrated greater gains.

Surgery plays a crucial role in global health care, improving the health and QOL for individuals facing various health challenges. Numerous studies have documented post-surgical complications, particularly in pulmonary and cardiac surgeries, leading to disturbed QOL.[15,16] Research has shown that physiotherapy before and after surgery can lead to better outcomes in these cases.[17–19] However, the effectiveness of physiotherapy exercises following abdominal surgeries has been less frequently explored.

Within-group analyses for Groups A and B were conducted for all outcome measures. The Mann–Whitney *U* test revealed significant improvements in VAS, ADL, and muscle strength, with $P < 0.001$ for all measures. Even the group that received strength training showed enhancements across all variables. A previous study by Stessel *et al.*[20] suggested that pain relief following open abdominal surgery can be influenced by patients' anxiety levels, with breathing and relaxation exercises helping to alleviate pain by reducing stress. Similarly, Bozorg *et al.*[21] found that rhythmic breathing techniques benefited post-burn patients by promoting the release of pain-relieving substances. Our study corroborates these findings, indicating that breathing techniques can serve as an effective non-pharmacological approach to pain management. According to the gate control theory, when the brain's descending and inhibitory fibers outnumber the input from small fibers, the "gate" to pain is closed, allowing relaxation to diminish or eliminate pain through inhibitory impulses from the cerebral cortex and thalamus.

A study by Hemingway *et al.*[22] demonstrated increased abdominal oblique muscle strength during rehabilitation

Table 4: Within-group analysis of QOL for both the groups

Group		QOL	*P* value
Intervention group	QOL-D1	QOL-D1-base	<0.001
		QOL-D1-1 month	<0.001
	QOL-D2	QOL-D2-base	<0.001
		QOL-D2-1 month	<0.001
	QOL-D3	QOL-D3-base	<0.001
		QOL-D3-1 month	<0.001
	QOL-D4	QOL-D4-base	<0.001
		QOL-D4-1 month	<0.001
Control group	QOL-D1	QOL-D1-base	<0.001
		QOL-D1-1 month	<0.001
	QOL-D2	QOL-D2-base	<0.001
		QOL-D2-1 month	<0.001
	QOL-D3	QOL-D3-base	<0.001
		QOL-D3-1 month	<0.001
	QOL-D4	QOL-D4-base	<0.001
		QOL-D4-1 month	<0.001

Based on estimated marginal means, the mean difference is significant at the $P < 0.05$ level; Adjustment for multiple comparisons: Bonferroni
QOL = Quality of life

Table 5: The between-group comparison of outcomes

Outcome measure	*F*	*P* value	Effect size (partial eta squared)
VAS	0.597	0.441	0.003
STRENGTH	19.536	0.000	0.097
ADL	0.012	0.914	0.000
QOL_D1	0.170	0.681	0.001
QOL_D2	0.718	0.398	0.004
QOL_D3	1.811	0.180	0.010
QOL_D4	1.542	0.213	0.008

QOL = Quality of life, VAS = visual analog strength, ADL = activities of daily living

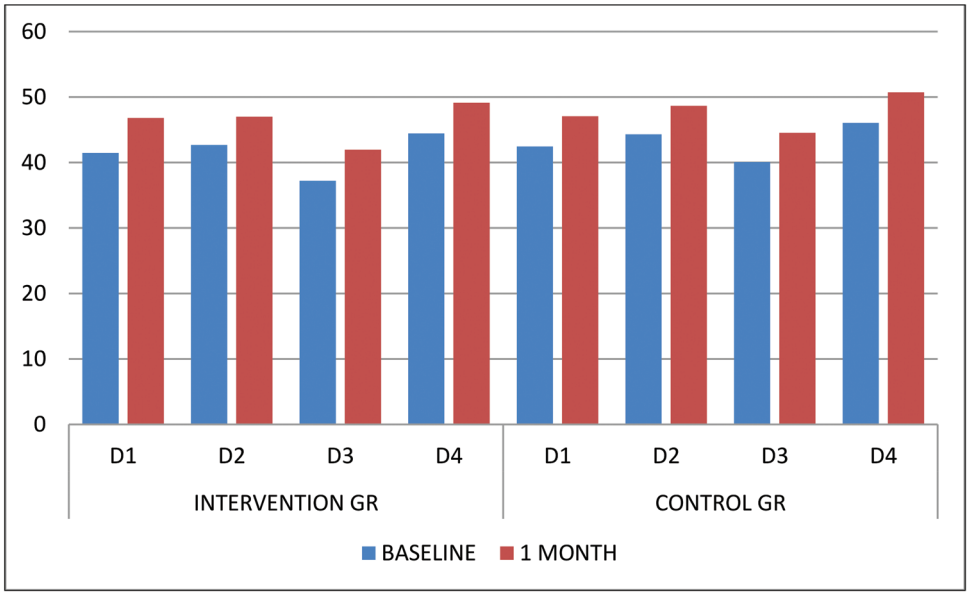

Figure 4: Within-group analysis of quality of life

after abdominal wall surgery, supporting our findings. Strengthening the abdominal and pelvic muscles can reduce the risk of complications such as abdominal weakness and low back pain. Enhancing strength while reducing pain in the immediate postoperative period may also shorten hospital stays.

Initiating structured exercises in the immediate postoperative period can accelerate recovery, reducing the risk of pulmonary complications and muscle atrophy. Targeted breathing and core-strengthening exercises may help minimize postoperative pulmonary issues (e.g., atelectasis) and incisional hernias by improving diaphragmatic function and abdominal wall stability. Beyond physical benefits, early rehabilitation may improve mental health by reducing anxiety and depression linked to prolonged immobility and pain. Clinicians should consider individualized exercise regimens based on surgical type and patient tolerance to optimize outcomes.

The study's findings may not be universally applicable to all genders, as it included a higher number of females than males. Physiological and biomechanical differences between genders can affect pain perception, abdominal muscle recovery, and responses to respiratory and strength training interventions. Additionally, due to the availability of patients, a first-come, first-served randomization technique was employed, which limited gender equality in the sample. Future research should aim for a more balanced gender representation to validate these findings across a broader range of populations.

Future studies should explore abdominal strength training with various outcome measures. We utilized the Chattanooga pressure biofeedback device to assess abdominal strength, which measures both strength and endurance; however, our study focused solely on strength. Future research could benefit from evaluating both strength and endurance. Although pain and muscle strength alone may not directly influence QOL, their improvement contributes to better functional outcomes and overall life satisfaction.

Conclusion

This study provides evidence supporting the benefits of respiratory and abdominal strength training exercises for patients recovering from abdominal surgeries. Implementing these exercises early in the postoperative period can enhance overall rehabilitation, helping to prevent complications, reduce hospital stays, and improve both physical and mental well-being.

Author contributions

The first author has conducted the study, collected the data, and prepared the manuscript. I am thankful to the research volunteers who have helped in the data collection. We extend our deepest gratitude to all the patients who participated in the study.

Ethical policy and Institutional Review Board statement

Ethics approval taken from the Institutional Ethics Committee of Parul University Human Research (PU-IECHR), Vadodara, Approval vide PU-IECHR/PIMSR/00/081734/2601. The study complies with the ethical principles outlined in the Declaration of Helsinki.

Declaration of patient consent

Necessary informed written consent was taken from the participants.

Data availability statement

Data will be shared on specific request to the author, depending upon the nature and purpose of the requirement.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Acknowledgements

Nil.

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