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Effect of Respiratory Muscle Training on Cough Efficacy, Functional Recovery and Length of Stay Post-Open-Abdominal Surgery: A Single Blinded Randomised Controlled Trial

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ABSTRACT

Introduction: Abdominal surgery is associated with post-operative depressed cough efficacy which results in the pooling of secretions, altered pulmonary function and an increased risk of postoperative pulmonary complications (PPCs) leading to a prolonged length of hospital stay (LOS). Physiotherapy interventions, such as respiratory muscle training (RMT), have been implemented post-abdominal surgery with the aim to enhancing inspiratory muscle strength. However, it is unclear whether the increased strength translates to an improved cough.

Aim: To assess the effect of RMT in comparison with conventional chest physiotherapy (DBEx) on cough efficacy, functional recovery and length of stay (LOS) post-abdominal surgery.

Method: This is a single blinded randomized controlled trial with thirty-six (36) patients scheduled for elective abdominal surgery. Participants were randomly assigned into experimental (Exp) and control (Ctl) groups. Exp Group received RMT & Early Mobilization (EM), Ctl Group received DBEx and EM. The outcome variables include; peak cough flow (PCF), functional recovery, LOS and pulmonary function. Inferential statistics of Analysis of Variance (ANOVA) was used to evaluate the significant difference in the 3 stages of data collection (pre-op, immediate post-op and post-op day 7 (POD7) or discharge (if discharged before POD7). Independent t-test was used to compare the outcome variables between the groups.

Result: 32 participants completed this study. In both groups, ANOVA showed a significant decrease in PCF, BIS and pulmonary function at immediate post-op followed by an increase at discharge or POD7. There was no statistically significant difference between the 2 groups following the t-test analysis in all variables.

Conclusion: RMT or DBEx in addition to EM will improve cough efficacy, functional recovery, LOS and pulmonary function post-abdominal surgery. None is more effective than the other in the management of patients' post-abdominal surgery.

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Keywords: Abdominal Surgery, Cough Efficacy, Respiratory Muscle Training, Functional Recovery, Length of Hospital Stay

Introduction

Abdominal surgery is the most common type of major surgery [1]. It significantly impacts postoperative pulmonary function, as observed by impairment of lung volumes (total lung capacity, vital capacity and tidal volume), oxygen arterial pressure and oxygen-haemoglobin saturation [2]. These alterations are associated with the residual impact of the anaesthesia administered, duration of surgery, incision site and length, immobilization in bed, muscle relaxants, and abdominal distension which initiate a cascade of pathophysiological responses including inefficient cough mechanism [3,4].

Cough serves as a natural protective mechanism that along with mucociliary clearance, protects the respiratory tract from foreign bodies and helps with clearing excessive bronchial secretions [5]. The normal cough mechanism which involves taking a deep breath, closing the glottis and compressing abdominal and thoracic muscles to generate a strong cough is weakened following abdominal surgery. This is due to impairment of respiratory muscle function, depression of mucociliary clearance and suppression of the cough reflex leading to the pooling of secretions and reduced lung volumes [4,6]. In addition to these, pain from the incision site and the psychological stress that a strong cough may aggravate the pain and damage the incision site further reduce cough efficacy [7].

A study reported that cough efficacy measured by peak cough flow rate dropped to 54% of the preoperative value on post-operative day (POD) 1; and on POD 5, peak cough flow was still significantly lower in relation to the preoperative values. Meanwhile, it has been identified that patient's inability to cough effectively increases the risk of obstructive atelectasis and lung infection, with a resultant decline in functional ability and increase length of hospital stay (LOS) [3-8].

Airway clearance techniques such as deep breathing exercises, Active Cycle of Breathing Technique (ACBT), early mobilisation and respiratory muscle training have been widely introduced and applied in post-operative clinical practice [1]. Respiratory muscle training (RMT) has been shown to be effective in improving respiratory muscle strength following abdominal surgery [9,10]. While the positive impact of RMT on respiratory muscle strength is well documented, it is expected that the increased strength should translate to enhanced cough, however, the evidence supporting RMT's impact on cough efficacy remains sparse.

Furthermore, despite advancements in perioperative anaesthetic techniques, 40 to 50% of patients undergoing open abdominal surgery experience a decline in pulmonary and physical function within the first 24 hours to 5 days post-operation [1,11]. However, improving airway clearance is expected to enhance lung volumes, improve patients' functional ability and reduce their hospital stay [12,13]. Hence, this study aimed to assess the effect of respiratory muscle training (RMT) in comparison with conventional chest physiotherapy (Deep breathing exercises) on cough efficacy, functional recovery and length of stay (LOS) within the first week post-abdominal surgery.

Methods

The study was reported using CONSORT guidelines for RCTs. This Randomized Controlled Trial involved thirty-six (36) patients scheduled for abdominal surgery who were recruited 1 - 2 days pre-operation from the Lagos University Teaching Hospital, Idi-Araba, Lagos, Nigeria. Ethical clearance was approved by the Health Research and Ethics Committee of Lagos University Teaching Hospital (Approval number - ADM/DCST/HREC/APP/3354). Participants included in this study were patients scheduled for elective abdominal surgery (such as, laparotomy, caesarean section, myomectomy/hysterectomy, salpingectomy, cystectomy, colectomy, colostomy, cholecystectomy). Patient scheduled for laparoscopy, intubated, on ventilator, and unconscious were excluded from this study. Written informed consent was obtained from each participant after the aim and procedures of the study had been clearly explained to them.

The participants were selected consecutively, and those who met the inclusion criteria were randomly assigned into two groups (Experimental and Control) using the fishbowl simple random sampling technique. Concealed allocation and participant blinding were ensured. The experimental group received respiratory muscle training with early mobilization (RMT & EM) from first day post-operation 2-times daily till discharge (for participants who were discharged before POD 7 (post-operative day 7)) or to POD7. While, control group received deep breathing exercise and early mobilization (DBEx & EM) from first day post-operation 2-times daily till discharge or to POD7.

Data was collected at 3 stages (Baseline/pre-operation, 24-hours post-operation and at discharge or POD7). The primary outcomes were cough efficacy using peak cough flow (PCF), functional recovery using Barthel Index Score and 10-meter walk test (10MWT) and LOS while the secondary outcomes were oxygen saturation (SpO_2) and pulmonary function test (FVC, FEV1).
The sample size was determined using formula [14].

$$n = N\frac{(Z\alpha\ +\ Z\beta)2}{\mathrm{ES2}}$$

n = number of sample size for all groups N=number of groups
α = confidential interval of 0.05 Zα = 1.96
β = confidential power of 80% Zβ = 0.84
ES = Effect size using Cohen's standard is 0.7
n = 2 [(1.96 + 0.84)2 / (0.7)2] = 32
Attrition rate= 10% of 32 = 3.2
Sample size: 32 + 3.2 = 35.2 approximately 35

The recruitment and stages of this study is simplified in Figure 1 flow chart

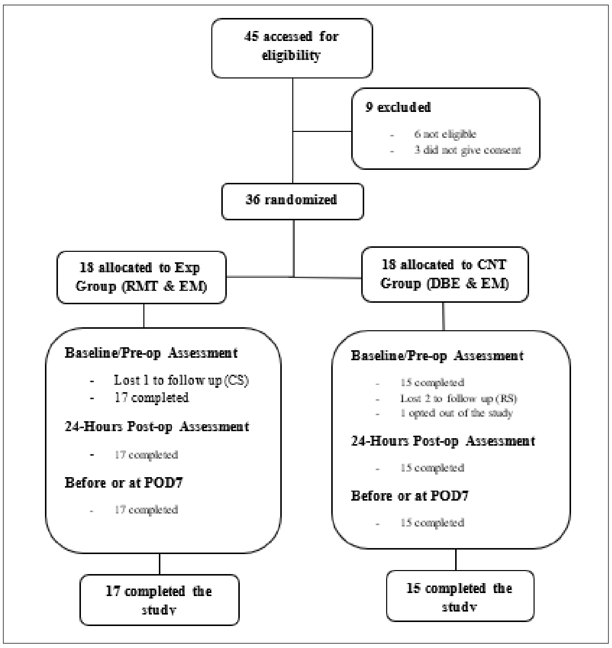


Figure 1: Flow Chart Representation for Participant Recuirtment and Stages of Assessment

Keys
RMT- Respiratory Muscle Training
EM- Early Mobilization
BE- Deep Breathing Exercise
RS- Rescheduled surgery
CS- Cancelled surgery
POD7- Post-operative day 7

Baseline/ Pre-Op Assessment

The assessment started with the evaluation of vital signs and general observation (drains, IV lines, urinary catheter) The primary and secondary outcome parameters were assessed and recorded at this stage.

Primary Outcome Parameters

Cough Efficacy

The "Mini-Wright Clement Clarke Peak Flow Meter" was used. It is a hand-held device with scale ranging from 60-800l/min. It is considered a relevant measure of cough efficacy [15]. The participants in long sitting or semi-fowler position were instructed to take in a deep breath, tightly cup their lips around the mouthpiece of the peak cough flow device and maximally exhale with a huff into their expiratory reserve volume [3,15]. This procedure was repeated thrice and the highest value was recorded. They were required to place their pillow on the incision site for support to prevent gapping during the post-operative stage assessments.

Functional Level Assessment
This was assessed using the Barthel index questionnaire and 10MWT. Barthel Index questionnaire was used to measure the functional level of each participant in relation to their activity of daily living and particularly what they could do as reported by their family/carera and nurse or by direct testing [16]. It is a 10-item questionnaire with a test-retest reliability of 0.89 and an internal consistency of 0.87 to 0.97. Scores range from 0 to 20, with lower scores indicating greater disability, and unconscious patients scoring 0 [16]. A 10-meter walk test (10MWT) was carried out at discharge or at POD7 at comfortable and fast walking speed for each participant following the Academy of Neurologic Physical Therapy 10MWT assessment protocol [17]. Materials used for the 10MWT include a digital stopwatch ("QUARZ", made in France), a Stanley Powerlock 25' tape measure and cones.

Length of Hospital Stay (LOS): Each participant's LOS was noted at their discharge day as documented in the case note.

Secondary Outcome Parameters
Oxygen Saturation
A pulse oximeter was used to measure the oxygen saturation of the

Pulmonary Function Test
A portable hand-held spirometer (CONTEC- SP10) was used in this study following the ATS/ERS (2019) protocol was used for the measurement of forced vital capacity (FVC) and forced expiratory volume in the first second (FEV1) [18].

Interventions
Experimental Group
Participants in this group received Respiratory Muscle Training (RMT) and early mobilization (EM). The recommended protocol for the use of breather device (129×43×46mm FDA Class1 (1058052) produced by PN Medical) by Katsura et al, and Mans et al, was followed for the RMT. The device applies resistance by breathing through different-sized orifices, thus increasing respiratory muscle strength [10,19]. Resistance is applied to both phases of the breath cycle causing increased strength of the muscles of respiration [20]. In a semi-fowler position with the foot flat on the bed, the participants were instructed to breathe in and out through the mouthpiece of the Respiratory resistive device (not the nose), and inhale deeply for 2-3 seconds, hold (1second), then exhale forcefully for 2-3seconds. An audible airflow sound was heard that offers biofeedback. The participants were encouraged to apply slight pressure using a pillow to support the incision site and a pulse oximeter was clipped on the left index finger to monitor the pulse rate and blood oxygen saturation during the procedure.

RMT Prescription
Frequency
3 sets of 4 cycles of inspiration and expiration with a rest after each set.
This procedure was carried out three times daily for 7 days or discontinued at discharge.
First set (morning); under supervision by the researcher, second and third set (afternoon and evening) was self-administered with confirmation from the carer/or attending nurse.

Intensity
Depending on the participants vital signs and tolerance, the resistance of the RMT device was increased by 1 step daily.

Control Group
Participants in this group received Deep Breathing Exercise (DBEx) following the protocol by Ahmad and early mobilization [21].

Protocol for Early Mobilization (EM)
The early mobilization protocol followed in this study can be seen on Table 1 [22].

Table 1: Protocol for Early Mobilization

Early Mobilization Protocol (Ahn et al, 2013)	
Post Operative Day (POD)	**Exercise Program**
POD1	Supervised - Stretching (neck, shoulder, wrist, ankle, knee, and pelvis) - Core exercises (isometric contractions and pelvic tilt) 10 reps * 2 sets) - Resistance (manually with therapist hand); ankle, knee, pelvis, shoulder, elbow and wrist. 10 reps * 2 sets - Progressive mobilization; sit, stand with pelvic tilt, walk around bed side with zimmers frame Supervised: Sitting (10mins), Standing (5mins), walking around bed with zimmers frame side as tolerated
POD2	Supervised (morning) - Stretching (whole body, leg, and shoulder) - Core exercises (isometric contractions, pelvic tilt, one leg raise) 10 reps * 3 sets - Resistance (manually); chest, shoulder, arm, thigh, and calf. 12 reps * 3 sets - Sit, stand and walk Supervised (evening): Sitting (20mins), Standing (>5mins), walking around the ward with zimmers frame
POD3	Supervised (morning) - Stretching (whole body, leg, and shoulder) - Core exercises (pelvic tilt, bridge, one & alternate leg raise) - Resistance with 1.5kg sand bag: chest, shoulder, arm, thigh, and calf. 12 reps * 3 sets Unsupervised (evening): Sitting (30mins), Standing (10mins), walking around without support

POD4	Supervised (morning) - Stretching, core exercises and resistance exercises as POD3 - Balance exercises: one leg standing, one leg calf raise, hip adduction, hip abduction, hip flexion with knee bent, hip extension. Unsupervised (evening): Sitting (> 1hour), Standing (>10mins), walking around without support
POD5 – POD7	Supervised (morning): continue as POD4 Unsupervised (evening): Sitting (2hours), Standing (>10mins), walking outside the ward corridor as tolerated

Key
POD- Post Operative Day

Post-Intervention Assessment
All the outcome parameters were assessed twice after the surgery; at 24-hours post-operation and at discharge or POD7. The 10-meter walk test (10 MWT) was assessed only at discharge or at POD7.

Data Analysis Using
Shapiro-wilk test showed that the data was normally distributed. Descriptive statistics of frequencies, percentages, mean and standard deviation were used to summarize the data. Within each group, repeated measures ANOVA was used to determine the significant difference in the different stages of data collection while independent t-test was used to determine the difference between the 2 groups.

Results
Thirty-two patients (81.3% females) completed this study with a mean age of 44.09+12.30 years. Table 2 shows the general characteristics of the participants involved in this study.

Table 2: General Characteristic of the Participants

Characteristics	Type	Exp Group	Ctl Group
		Freq / n(%)	Freq / n (%)
Gender	Male Female	4 13	2 13
Surgery	Colostomy Colectomy Caesarean section TAH + BSO Gastrojujunostomy Salpingo-oophorectomy Myomectomy Cholecystectomy	4 2 4 4 1 0 2 0	3 1 5 4 0 1 0 1
Incision Site	UA UA + LA LA	0 10 7	0 7 8
Anaesthesia	General Regional	16 1	14 1
		$\bar{X}$ ± SD (years)	$\bar{X}$ ± SD (years)
Age		41.94+11.82	46.53+12.78

Keys
UA- Upper Abdominal Incision
UA & LA- Upper and Lower Abdominal Incision
LA- Lower Abdominal Incision
TAH + BSO- Total Abdominal Hysterectomy with Bilateral Salpingo-oophorectomy

Table 3 shows the vital signs and outcome variables of all participants at the different stages of assessment.

Table 3: Pre-operative, 24 Hours, and Discharge Day variables for all participants (n = 32)

VARIABLES	Baseline/Pre-ope X̄ ± SD	24-Hours Post-ope X̄ ± SD	Discharge or POD 7 X̄ ± SD
SBP (mmHg)	119.47 + 15.29	122.03 + 12.48	123.09 + 14.18
DBP (mmHg)	77.83 + 10.39	80.16 + 8.55	80.23 + 9.54
PR (b/m)	83.00 + 10.12	87.22 + 10.27	84.25 + 7.39
RR (c/m)	20.73 + 1.85	21.38 + 1.72	20.45 + 1.06
SpO2 (%)	97.53 + 1.01	97.50 + 1.81	97.91 + 0.86
PCF (L/min)	202.32+67.49	107.83+33.31	185.16 + 57.99
FVC (L)	1.73+0.74	1.03+0.24	1.62 + 0.63
FEV1 (L)	1.65+0.67	0.20+0.24	1.58 + 0.59
BIS	18.37+4.12	9.59+3.35	18.72 + 3.12
LOS (days)	---------	---------	5.63 + 1.79
CWS (m/s)	---------	---------	0.235 + 0.09
FWS (m/s)	---------	---------	0.28 + 0.11

Keys
SpO_2- Oxygen-haemoglobin Saturation level
PCF- Peak cough flow rate
BIS- Barthel index score
CWS- Comfortable walking speed
FVC- Forced vital capacity
FEV1- Forced expiratory volume in 1 second
SBP- Systolic Blood Pressure
DBP- Diastolic Blood Pressure
RR- Respiratory Rate
PR- Pulse Rate
FWS- Fast walking speed
POD7- Post-operation day 7

Following the ANOVA statistical test, within each group, there was a significant drop in all outcome variables immediately following surgery, however, this significantly improved at discharge or POD7 (Table 4).

Table 4: Therapeutic Efficacy within the Groups

Exp. Group (RMT&EM) n= 17	Pre-operation X̄ ± SD (a)	24-hours post-op X̄ ± SD (b)	Discharge or at POD7 X̄ ± SD (c)	F-value	p-value	Post Hoc
PCF(L/min)	199.64 + 72.66	117.86 +40.80	205 + 57.48	22.67	0.001*	a&b, b&c
FVC (L)	1.80 + 0.89	1.06 + 0.30	1.85 + 0.81	13.90	0.001*	a&b, b&c
FEV1 (L)	1.72 + 0.81	1.03 + 0.27	1.80 + 0.76	14.45	0.001*	a&b, b&c
BIS	18.94 + 3.17	9.94 + 3.84	19.50 + 1.16	84.29	0.001*	a&b, b&c
SpO_2 (%)	97.56 + 0.89	97.19 + 2.23	97.88 + 0.89	1.20	0.297	
Ctl. Group (DBEx &EM) n= 15	Pre-operation X̄ ± SD (a)	24-hours Post-op X̄ ± SD (b)	Discharge or at POD7 X̄ ± SD (c)	F-value	p-value	Post Hoc
PCF(L/min)	205.00 + 64.54	100.36 + 24.06	173.21 + 56.73	31.57	0.001*	a&b, b&c
FVC (L)	1.65 + 0.58	1.01 + 0.17	1.50 + 0.37	18.35	0.001*	a&b, b&c
FEV1 (L)	1.59 + 0.53	0.98 + 0.18	1.47 + 0.34	22.21	0.001*	a&b, b&c
BIS	17.71 + 5.03	9.21 + 3.02	18.14 + 4.24	69.60	0.001*	a&b, b&c
SpO_2 (%)	97.50 + 1.16	97.86 + 1.23	97.93 + 0.83	1.26	0.295	

Shows significance at $p< 0.05$

Keys
F-value- Repeated Measures
SpO2- Oxygen-Haemoglobin Saturation Level
PCF- Peak Cough Flow Rate
FVC- Forced Vital Capacity
BIS- Barthel Index Score
POD7- Post-Operation Day 7
FEV1- Forced Expiratory Volume in One Second

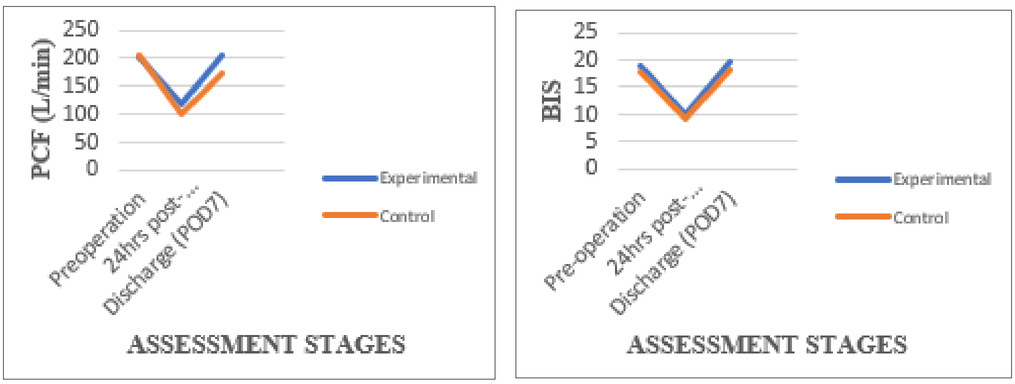
Between groups, independent t-test (Table 5) showed no significant difference in the outcome variables at the different stages of assessment, however, some clinical differences were noted in the variables except for functional ability (BIS) (Figure 2).

Table 5: Comparison of the Outcome Variables between the Groups

VARIABLES	Exp. Group X̄ ± SD (n = 17)	Ctl. Group X̄ ± SD (n = 15)	t-value	p-value
Baseline/ Pre-operative Stage SpO2 PCF FVC FEV1 BIS	97.56 + 0.89% 199.64 +72.66 L/min 1.804+0.89 L 1.72+0.81 L 18.94+3.17	97.50 + 1.16% 205.00+64.54 L/min 1.65+0.58 L 1.59+0.53 L 17.71+5.03	0.167 -0.206 0.557 0.519 0.807	0.869 0.838 0.582 0.608 0.426
24-Hours Post-operative Stage SpO2 PCF FVC FEV1 BIS	97.19 + 2.23% 117.86+40.8 L/min 1.06+0.30 L 1.03+0.27 L 9.94+3.84	97.86 + 1.23% 100.36+24.06 L/min 1.01+0.17 L 0.98+0.18 L 9.21+3.02	-1.283 1.245 0.097 0.000 0.408	0.209 0.224 0.924 1.000 0.686
Before or at POD7 SpO2 PCF FVC FEV1 BIS LOS CWS FWS	97.88 + 0.89% 205.00+ 57.48 L/min 1.85 + 0.81 L 1.80 + 0.76 L 19.50 + 1.16 5.47 + 1.63 days 0.25 + 0.92 m/s 0.29 + 0.12 m/s	97.93 + 0.83% 173.21+ 56.73 L/min 1.50 + 0.37 L 1.47 + 0.34 L 18.14 + 4.24 5.80 + 2.01 days 0.22 + 0.09 m/s 0.26 + 0.11 m/s	-0.576 0.975 1.166 1.191 0.764 -0.513 0.727 0.758	0.569 0.338 0.253 0.243 0.451 0.612 0.473 0.454

Shows significance at $p < 0.05$

Key
t-value- Independent t-Tail
PCF- Peak Cough Flow Rate
FEV1- Forced Expiratory Volume
BIS- Barthel Index Score
10MWT- 10-Meter Walk Test
POD7- Post-Operation Day 7
CWS- Comfortable Walking Speed
FVC- Forced Vital Capacity in One Second
FWS- Fast Walking Speed
SpO_2- Oxygen-Haemoglobin Saturation Level



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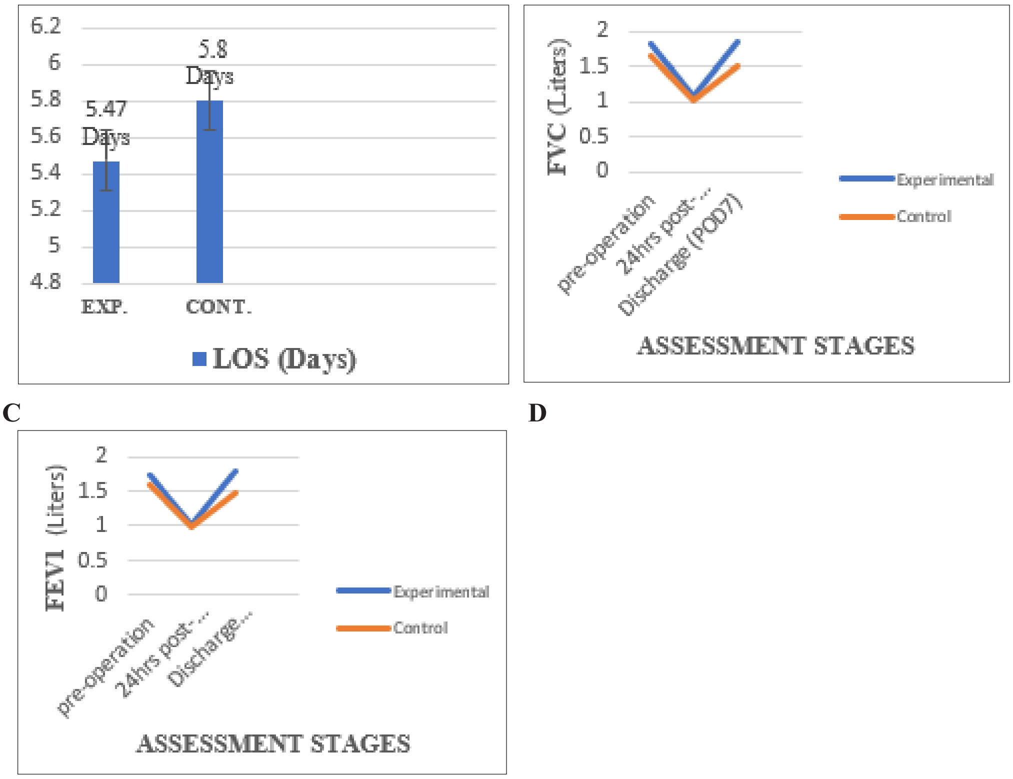

Figure 2: Clinical Differences in Outcome Variables

- Changes observed in the Cough Efficacy (PCF) across the stage of assessment for both groups
- Changes observed in the fuctional performance (BIS) across the stages of assessment for both groups
- Pattern of the Length of Hospital Stay (LOS) between both groups
- Changes observed FVC across the stages of assessment for both groups
- Changes observed in the pulmonary function (FEV1) across the stages of assessment for both groups

Discussion

The result of this study confirmed the hypothesis that RMT improves cough efficacy. It has been explained that cough efficacy depends on lung volume, respiratory and laryngeal muscle strength, and lung mechanics [5]. We found in this study that cough efficacy was restored to and beyond the pre-operative values following RMT, despite a 41% decline immediately post-surgery (POD1). This implies that RMT applied through resistive loads over a period with varying loads in response to patients' tolerance improves respiratory muscle strength and endurance, thus enhancing cough efficacy and lung volumes and reduces the clinical incidence of pulmonary diseases, such as pneumonia and atelectasis [23]. Our findings align with prior researches [3,10,19], including a pilot study involving 80 patients scheduled for major abdominal surgery, which showed significant improvements in respiratory muscle strength, elastic recoil and vital capacity (crucial to cough efficacy) following RMT among the participants. In comparison, though our study showed no statistical significance in cough efficacy between the groups, at discharge or POD7, the PCF of the participants in the experimental group had increased by 4.48% while those in control group was reduced (by 15.5%) when compared to their pre-operative value. This indicates a clinically important difference between the two groups.

Regarding functional ability, as expected, our study showed a significant decline (47.8%) in the Barthel index score (BIS) of participants in both groups following 24-hours post-operation compared to their pre-operative value which may have resulted from the operative course (anaesthesia, incision, duration of surgery), post-operative pain, general weakness and fatigue from pre-operative fasting till gas was passed and bowel movement returned [24,25]. However, this decline was followed by a significant improvement in BIS on the last day of the study for participants in both groups with no statistically significant difference. 10MWT, which was also used for functional recovery in this study was primarily aimed to evaluate the walking speed of the participants post-surgery. We believe that the lack of significant difference in functional recovery between the groups in our study may be owing to the adjunct intervention – Early Mobilization (EM). It has been well discussed in literature that EM is a crucial component of enhanced recovery after surgery (ERAS) that reverses the physiological consequences of surgery and immobilization [26]. EM accelerates recovery of functional walking capacity and positively impacts several patient-reported outcomes [26,27].

The body of literature has discussed LOS to be attributed to patient illness, complications post-surgery, management and prevention of complications, and style of medical practice [12,13,28]. In our study, only one participant (in the experimental group) required intensive care immediately post-operation while none of the participants was readmitted for intensive care, none had record of pneumonia, pleural effusion, infected incision site, or unstable stitches and the mean LOS was 5.47 + 1.63 for and 5.80 + 2.01. days for experimental and control groups respectively with no statistically significant difference observed between the groups. The studies by Kabir and Kendall showed that early mobilization in addition to other exercises such as DBEx or RMT significantly reduced LOS [29,30].

Regarding the secondary outcomes, our study agrees with the body of literature that has confirmed the efficacy of RMT and DBEx on pulmonary function. The systematic review by Mans agrees with our findings that RMT improves pulmonary function (FVC and FEV1). Similarly, it has reported that chest physiotherapy techniques, such as deep breathing and coughing exercises, improved ventilation, secretion clearance, and pulmonary capacity despite the initial decline in function [19,31]. Our study revealed no significant difference in the pulmonary function parameters between the groups – this implies that there is no absolute therapeutic benefit of RMT over DBEx on pulmonary function among patients' post-abdominal surgery, although, the results suggest that there may be a level of clinically significant difference between groups across the 3-stages of assessment as shown in the graphical representation of the result.

To conclude this study, both respiratory muscle training and deep breathing exercises, combined with early mobilization, improve cough efficacy, functional recovery, pulmonary function, and reduce hospital stay after abdominal surgery and RMT was not statistically significantly better than DBEx.

Limitations
A limitation of this study was a low sample size due to COVID-19 pandemic as many elective surgeries were delayed which led to recruiting more gynaecological surgeries participants and a skewed distribution of female participants.

Recommendations
According to the findings of this study, ensuring that abdominal surgery patients start respiratory physiotherapy particularly respiratory muscle training and early mobilization immediately post-operation is crucial to improve cough efficacy which is vital in the prevention of PPCs and shortened hospital stay.

Implication for Further Studies
It is suggested that a similar study with a larger sample size should be carried out.

References

1. Boden I (2024) Physiotherapy management of major abdominal surgery. Journal of Physiotherapy 70: 170-180.
2. Manzano RM, Carvalho CR, Saraiva-Romanholo BM, Vieira JE (2008) Chest physiotherapy during immediate postoperative period among patients undergoing upper abdominal surgery: randomized clinical trial. Sao Paulo Medical Journal 126: 269-273.
3. Colucci DB, Fiore JF Jr, Paisani DM, Risso TT, Colucci M, et al. (2015) Cough impairment and risk of postoperative pulmonary complications after open upper abdominal surgery. Respiratory Care 60: 673-678.
4. Kalil-Filho FA, Campos ACL, Tambara EM, Tomé BKA, Treml CJ, et al. (2019) Physiotherapeutic Approaches and the effects on inspiratory muscle force in patients with Chronic Obstructive Pulmonary Disease in the Pre-Operative Preparation for Abdominal Surgical Procedures. Arquivos Brasileiros de Cirurgia Digestiva 26: e1439.
5. Andrani F, Aiello M, Bertorelli G, Crisafulli E, Chetta A (2019) Cough, a vital reflex. mechanisms, determinants and measurements. Acta Biomedica 15: 477-480.
6. Lunardi AC, Paisani DM, Silva CCBMD, Cano DP, Tanaka C, et al. (2015) Comparison of lung expansion techniques on thoracoabdominal mechanics and incidence of pulmonary complications after upper abdominal surgery: a randomized and controlled trial. Chest 148: 1003-1010.
7. Shimoyama H, Sugiyama M, Suzuki Y, Teruya K, Ohki A, et al. (2021) Bilateral Flank Compression Maneuver for Reducing Pain on Coughing after Abdominal Surgery: A Prospective Study. Journal American College of Surgeons 233: 459-466.
8. Smith MC, Ellis ER (2000) Is retained mucus a risk factor for the development of postoperative atelectasis and pneumonia? Implications for the physiotherapist. Physiotherapy Theory Practices 16: 69-80.
9. Kulkarni SR, Fletcher E, McConnell AK, Poskitt KR, Whyman MR (2010) Pre-operative inspiratory muscle training preserves postoperative inspiratory muscle strength following major abdominal surgery - a randomised pilot study. Annals Royal College of Surgeon England 92: 700-707.
10. Katsura M, Kuriyama A, Takeshima T, Fukuhara S, Furukawa TA (2015) Preoperative inspiratory muscle training for postoperative pulmonary complications in adults undergoing cardiac and major abdominal surgery. Cochrane Database of Systematic Reviews 2015: CD010356.
11. Sasaki N, Meyer MJ, Eikermann M (2013) Postoperative respiratory muscle dysfunction: pathophysiology and preventive strategies. Anesthesiology 118: 961-978.
12. Rawlinson A, Kang P, Evans J, Khanna A (2011) A systematic review of enhanced recovery protocols in colorectal surgery. Annals of Royal College of Surgeons England 93: 583-588.
13. Hall WB, Willis LE, Medvedev S, Carson SS (2012) The implications of long-term acute care hospital transfer practices for measures of in-hospital mortality and length of stay. American Journal of Respiratory Critical Care Medicine 1: 53-57.
14. Sasaki N, Meyer MJ, Eikermann M (2013) Postoperative respiratory muscle dysfunction: pathophysiology and preventive strategies. Anesthesiology 118: 961-978.
15. Fiore MC, Jaen CR, Baker TB (2008). Treating Tobacco Use and Dependence: Clinical Practice Guideline. ID: NBK63952.
16. Collin C, Wade DT, Davies S, Horne V (1988) The Barthel ADL Index: a reliability study. International Disability Study 10: 61-63.
17. Moore JL, Potter K, Blankshain K, Kaplan SL, O'Dwyer LC (2018) A Core Set of Outcome Measures for Adults with Neurologic Conditions Undergoing Rehabilitation: A CLINICAL PRACTICE GUIDELINE. Journal of Neurologic Physical Therapy 42: 174-220.
18. Graham BL, Steenbruggen I, Miller MR, Barjaktarevic IZ, Cooper BG, et al. (2019) Standardization of Spirometry 2019 Update. An Official American Thoracic Society and European Respiratory Society Technical Statement. American Journal of Respiratory and Critical Care Medicine 200: e70-e88.
19. Mans CM, Reeve JC, Elkins MR (2014) Postoperative outcomes following preoperative inspiratory muscle training in patients undergoing cardiothoracic or upper abdominal surgery: a systematic review and meta-analysis. Clinical Rehabilitation 29: 426-438.
20. Plowman EK, Watts SA, Tabor L, Robison R, Gaziano J, et al. (2016) Impact of expiratory strength training in amyotrophic lateral sclerosis. Muscle Nerve 54: 48-53.
21. Ahmad AM (2018) Essentials of Physiotherapy after Thoracic Surgery: What Physiotherapists Need to Know. A Narrative Review. Korean J Thorac Cardiovasc Surg 51: 293-307.
22. Ahn KY, Hur H, Kim DH, Min J, Jeong DH, et al. (2013) The effects of inpatient exercise therapy on the length of hospital stay in stages I-III colon cancer patients: randomized controlled trial. International Journal Colorectal Disease 28: 643-651.
23. Winkle MJ, Sankari A (2024) Respiratory Muscle

Strength Training. Stat Pearls Treasure Island (FL): StatPearls Publishing https://www.ncbi.nlm.nih.gov/books/NBK603753/.

24. Ajepe TO, Gbiri CAO, Akinbo SRA (2016) Comparative Efficacy of two Physiotherapy Approaches in Restoring Functional Performance in Individuals After Thoraci-abdominal Individuals: A Clinical Controlled Study. Nigerian Quarterly Journal of Hospital Medicine 26: 488-494.
25. Liang Y, Yan X, Liao Y (2021) The effect of shortening the preoperative fasting period on patient comfort and gastrointestinal function after elective laparoscopic surgery. American Journal of Translational Research 15: 13067-13075.
26. Tazreean R, Nelson G, Twomey R (2022) Early mobilization in enhanced recovery after surgery pathways: current evidence and recent advancements. Journal of Comparative Effectiveness Research 11: 121-129.
27. Jønsson LR, Foss NB, Orbæk J, Lauritsen ML, Sejrsen HN, et al. (2023) Early intensive mobilization after acute high-risk abdominal surgery: a nonrandomized prospective feasibility trial. Canadian Journal of Surgery 66: E236-E245.
28. Krell RW, Girotti ME, Dimick JB (2014) Extended length of stay after surgery: complications, inefficient practice, or sick patients?. Journal of the American Medical Association Surgery 149: 815-820.
29. Kabir MF, Jahan S, Hossain MZ, Chakrovorty SK, Sarker AH, et al. (2021) Effect of Chest Physiotherapy along with Early Mobility after Abdominal Surgery. European Journal of Medical and Health Sciences 3: 150-156.
30. Kendall F, Oliveira J, Peleteiro B, Pinho P, Bastos PT (2018) Inspiratory muscle training is effective to reduce postoperative pulmonary complications and length of hospital stay: a systematic review and meta-analysis. Disabil Rehabil 40: 864-882.
31. Kumar AS, Alaparthi GK, Augustine AJ, Pazhyaottayil ZC, Ramakrishna A, et al. (2016) Comparison of Flow and Volume Incentive Spirometry on Pulmonary Function and Exercise Tolerance in Open Abdominal Surgery: A Randomized Clinical Trial. Journal of Clinical and Diagnostic Research 10: KC01-KC06.