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EFFECTIVENESS OF DEEP BREATHING EXERCISE AND INCENTIVE SPIROMETRY ON OXYGEN SATURATION AND PEAK EXPIRATORY FLOW RATE IN POST-EXTUBATION ICU PATIENTS: A QUASI-EXPERIMENTAL STUDY

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ABSTRACT

Background: Reintubation of patients in the ICU due to respiratory failure is a serious problem in medical world. Supportive therapy is needed for breathing exercises to prevent reintubation due to respiratory muscle weakness. **Objective:** Aims to analyze effectiveness of deep breathing exercise and Incentive spirometry on oxygen saturation and peak expiratory flow rate in extubated patients. **Methods:** A quantitative, quasi-experimental design with 33 respondents (11 in the deep breathing group, 11 in the incentive spirometry group, and 11 in the combined deep breathing and incentive spirometry group), recruited through purposive sampling. The independent variable was the combination of Deep Breathing and Incentive Spirometry, implemented according to the module guidelines. The dependent variables were oxygen saturation, measured by pulse oximetry, and peak expiratory flow rate, measured by peak flow meter. Data were analyzed using a paired sample t-test. **Results:** Deep breathing exercises and incentive spirometry showed a significant effect on oxygen saturation, as shown in the combined results (p = 0.000; Delta = 4.55). Peak expiratory flow rate also showed significant deep breathing exercise and incentive spirometry interventions, with the most significance value in the combination intervention (p = 0.000; Delta = 130.27). **Conclusion:** The combination of deep breathing exercises and incentive spirometry interventions showed greater effectiveness, suggesting it may be a supportive intervention for post-extubation patients.

Keywords: Deep breathing exercise; Extubation; Incentive spirometry; Oxygen saturation; Peak expiratory flow rate:

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BACKGROUND

The incidence of respiratory failure leading to reintubation in patients after extubation is a serious problem in the medical world (Yasuda et al., 2021). Reintubation after extubation in intensive care unit (ICU) patients is a serious clinical problem. Extubation failure is often caused by respiratory muscle weakness, impaired airway clearance, or inadequate breathing effort, which may prolong hospital stay, increase healthcare costs, and raise the risk of complications (Ko et al., 2020; Chung et al., 2022; Krinsley et al., 2021; Yasuda et al., 2021).

Several studies have reported that the incidence of extubation failure ranges between 10% and 20% among ICU patients (Thille et al., 2011; Bansal et al., 2022 ; Epstein, 2017). Patients who experience extubation failure are at higher risk of hypoxemia and reduced peak expiratory flow rate (PEFR), which may contribute to adverse outcomes (Chen et al., 2023; Hirolli et al., 2023). In one study, approximately 9% of patients required reintubation, and among these, about 5% died during hospitalization (Banik et al., 2021). Local hospital data indicated a reintubation rate of 22% (unpublished data, Naval Central Hospital), suggesting that this problem may be more prevalent in specific clinical settings.

Efforts to overcome the decrease in SpO2 and PEFR in post-extubation patients include providing supplemental oxygen through a mask or nasal cannula to increase oxygen saturation (Thille et al., 2021). Nebulizer therapy with bronchodilators or inhaled steroids is used to help open the airways and increase airflow in and out of the lungs (Matsuda et al., 2020). In addition, respiratory physiotherapy involving breathing exercises, effective coughing techniques, and physical therapy is performed to improve lung ventilation and increase PEFR. Patients were placed in a semi-fowler position to maximize lung expansion and reduce the work of breathing, and continuous monitoring of vital signs, SpO2, and PEFR was performed (Cork et al., 2019; Wang et al., 2018). Nonetheless, reintubation problems remain common, underscoring the need for a more effective and integrated approach (Boscolo et al., 2023).

Without deep breathing intervention, there is a potential decrease in blood oxygen level (SpO2) as well as a decrease in PEFR. Previous studies have shown that deep breathing interventions improve blood oxygenation (SpO2) (Study A: from 80.2±7.7% to 89.5±8.2%; Study B: from 81.0±4.2% to 88.6±4.5%; both $p<0.001$) and PEFR (0.7187 and 0.7356) (Bilo et al., 2012; Joshi & Singh, 2023). The use of Incentive spirometry has also been shown to improve SpO2 and reduce the incidence of hypoxia from 30% to 3% (Chen et al., 2023). In a study on the use of incentive spirometry (IS) breathing exercise devices, a significant increase in oxygen saturation (SpO2) and peak expiratory flow rate (PEFR) scores was observed in the IS group compared to the control group (Franklin & Anju, 2023; Zeng et al., 2023).

The combined use of Incentive spirometry and deep breathing exercises can improve SpO2 and PEFR and prevent reintubation through mutually supportive mechanisms. The use of incentive spirometry and deep breathing exercises helps increase lung volume, strengthen respiratory muscles, and improve ventilation oxygenation of the lungs (Chen et al., 2023). Breathing exercises can improve alveolar ventilation by expanding the alveoli and increasing tidal volume, thus aiding a more even distribution of air throughout the lungs. Combining incentive spirometry and deep breathing exercises works synergistically to open more alveoli and maintain alveolar patency, which is crucial in maintaining optimal gas exchange (Zeng et al., 2023).

Solutions to address post-extubation reintubation for respiratory failure require a holistic approach (Casey et al., 2019). The focus is on providing intensive and targeted breathing exercises in accordance with Orem's Self-Care Theory. This theory posits that individuals possess the capacity to care for themselves in order to achieve optimal health (Hartweg & Metcalfe, 2022; Yip, 2021). In the context of extubation, this theory encourages patients to actively engage in self-care, including performing breathing exercises. This involves supporting post-extubation patients in independently performing breathing exercises using intensive spirometry and deep breathing techniques (Uslu & Canbolat, 2022).

Deep breathing interventions and the use of incentive spirometry have been shown to be effective in improving SpO2 and PEFR in patients with compromised respiratory conditions (Bilo et al., 2012; Joshi & Singh, 2023). However, no studies have specifically combined these two interventions to address the issue of post-extubation reintubation. By combining deep breathing exercise and incentive spirometry, it is expected to provide a synergistic effect in improving respiratory function and oxygenation, thus preventing a decrease in SpO2 and PEFR that can cause reintubation. Deep breathing exercises can help expand lung capacity and improve alveolar ventilation, while incentive spirometry helps train and strengthen respiratory muscles. The combination of these two interventions is more effective in preventing reintubation compared to a single intervention.

METHODS

This study employed a quantitative method with a quasi-experimental design, which aimed to examine the causal relationship by involving control and experimental groups. The design used was a pretest - posttest design. The experimental group consisted of patients who received deep breathing exercises, incentive spirometry, and a combination of both interventions in the ICU room at RSUD Haji, East Java, Surabaya. Quasi-experimental studies typically use subject groups using cluster techniques, so that from the outset, the two subject groups may have different characteristics (Nursalam, 2020). The following is a table 1 of the research design used.

The population in this study consisted of post-extubation patients who were hospitalized in the ICU room of RSUD Haji East Java Surabaya between March and May 2024. The sample consists of part of the affordable population used as research subjects through a sampling process. Inclusion criteria: adult patients who have been extubated for at least 1 hour, patients with compos mentis level of consciousness, and postoperative patients who have received general anesthesia. Sampling in this study employs a purposive sampling technique, which is a type of non-probability sampling.

The inclusion criteria for this study consisted of adult patients who had been extubated for at least one hour, were fully conscious (compos mentis), and had previously undergone surgery under general anesthesia. These criteria were selected to ensure that participants had sufficient cognitive and physical ability to perform the breathing exercises independently.

Patients were excluded from the study if they exhibited impaired consciousness following extubation, sustained severe rib injuries, or had undergone abdominal or ocular surgery, as these conditions could limit their ability to perform deep breathing or incentive spirometry safely. In addition, patients with a diagnosed aneurysm were excluded due to the potential hemodynamic risks associated with increased intrathoracic pressure during respiratory maneuvers.

Dropout criteria included patients who failed to complete at least one intervention session during the research process. After applying these criteria, a total of 33 respondents were enrolled in the study: 11 participants in the deep breathing exercise group, 11 in the incentive spirometry group, and 11 in the combined intervention group. Based on calculations using the formula for calculating sample size (n) in limited population research. Sample size calculation: The minimum sample size was calculated using the Lemeshow formula for quantitative experimental studies:

Calculations to anticipate sample dropouts, which amount to 10% of the calculated sample. The calculation for correcting the sample size for dropouts is as follows (Sujarweni, 2015).

The intervention procedures were carried out in three groups under the direct supervision of ICU nurses. In the deep breathing exercise (DBE) group, each patient performed ten deep breaths per cycle, which were repeated for three cycles in each session. The intervention was administered twice daily, ensuring that patients maintained consistent breathing depth and rhythm throughout the exercise. The intervention was administered twice daily, ensuring that patients maintained consistent breathing depth and rhythm throughout the exercise. In the incentive spirometry (IS) group, patients were instructed to use an incentive spirometer device to perform ten slow and sustained inspirations per cycle, repeated for three cycles per session, also conducted twice daily under close supervision. The visual feedback provided by the spirometer encouraged patients to achieve optimal inspiratory volumes and maintain alveolar inflation. The visual feedback provided by the spirometer encouraged patients to achieve optimal inspiratory volumes and maintain alveolar inflation. In the combination group, participants performed the DBE exercise followed immediately by the IS intervention, following the same number of cycles and sessions per day. This sequence aimed to maximize the synergistic effects of diaphragmatic expansion through DBE and alveolar recruitment through IS, promoting enhanced pulmonary ventilation and oxygenation. All interventions were implemented consistently according to the module guidelines and standardized operating procedures to ensure reliability and comparability of outcomes among groups.

Two primary physiological parameters were assessed in this study: oxygen saturation (SpO2) and peak expiratory flow rate. Oxygen saturation was measured using a validated pulse oximeter with an accuracy level of ±2%, certified by the US Food and Drug Administration (FDA) and the Conformité Européenne (CE). Peak expiratory flow rate was assessed using a calibrated peak flow meter with a reliability coefficient of at least 0.85, ensuring measurement precision and reproducibility. Both parameters were recorded at baseline, prior to the intervention, and again 30 minutes after completion of each session to evaluate the immediate physiological

Table 1. Quasi-experimental pre-post test research design

Subject	Pretest	Intervention	Post-test
K- intervention 1	01	IA	01-A
K- intervention 2	02	IB	02-B
K-intervention 3	03	IC	03-C
	Time 1	-	Time 2

Description:
K-intervention 1: Subject (post-extubation patients) in the intervention group of deep breathing exercises.
K-intervention 2: Subject (post-extubation patients) intervention group of incentive spirometry.
K-intervention 3: Subject (post-extubation patients) intervention group of a combination of deep breathing and incentive spirometry.
IA : deep breathing therapy intervention.
IB : incentive spirometry therapy intervention.
IC : combination therapy intervention of deep breathing and incentive spirometry.
01-A : measurement of oxygen saturation and PEFR after implementation of deep breathing.
02-B : measurement of oxygen saturation and PEFR after implementation of incentive spirometry.
03-C : measurement of oxygen saturation and PEFR after implementation of a combination of incentive spirometry deep breathing.

$$n1 = n2 = 2 \left\{ \frac{(Z\alpha + Z_{\beta})\, S^{2}}{x1 - x2} \right\}$$

$$n1 = n2 = 2^{2}$$

$$n1 = n2 = 2 \left\{ \begin{matrix} \frac{(1.96 + 0.842)\, 2.58}{1.87} \\ \left\{ \frac{18,4943}{1.87} \right\} \end{matrix} \right\}$$

$$n1 = n2 = 9,89$$

$$n1 = n2 = 10$$

Figur 1. the Lemeshow formula

Explanation:
n : Sample size
Z alfa : Type error (beta = 80% = 0.84)
Z beta : Type error (alfa 5% = 1.96)
S : Standard deviation of both groups k
x1- x2 : difference in research averages

effects of exercises. All measurements were performed under standardized conditions in ICU environment, with patients in a semi-Fowler's position to optimize respiratory effort and minimize measurement variability.

Data were analyzed using a paired t-test for within-group comparisons. Ethical considerations in this study was approved by the Health Research Ethics Committee of RSUD Haji Surabaya with clearance number No. 445/49 /KOM.ETIK/2025. Written informed consent was obtained from all participants.

RESULT

The characteristics of the respondents in this study were based on complications, length of time on the ventilator and comorbidities. Data on the characteristics of respondents were first tested for homogeneity to confirm that respondents from the deep breathing exercise group, incentive spirometry, and the combination of

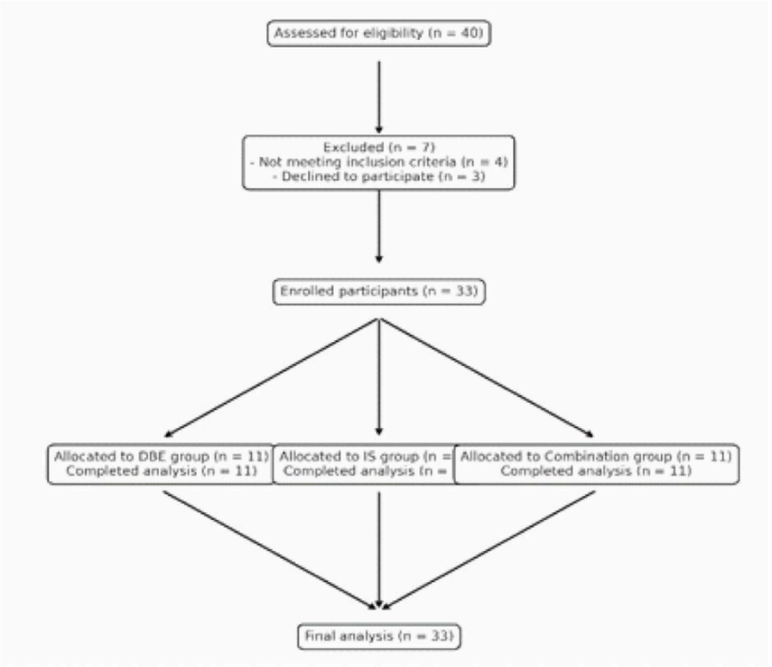

Figure 2. Flowchart intervention

Table 2. Effect of the combination of deep breathing and incentive spirometry on oxygen saturation in post-extubation patients

Variable	**Pretest (Mean ± SD)**	**Posttest (Mean ± SD)**	**Δ value**	**P value**
Oxygen Saturation	94.45±0.820	99.00±1.000	4.55	0.000 *

Table 3. Effect of the combination of deep breathing and incentive spirometry on peak expiratory fow in post-extubation patients

Variable	**Pretest (Mean ± SD)**	**Posttest (Mean ± SD)**	**Δ value**	**P value**
Peak ekspiratory flow	325.09±53.174	455.36±44.367	130.27	0.000 *

both were equivalent. The results of the homogeneity test showed a p-value >0.05, no significant differences among the three groups in terms of research respondents.

The results of inferential analysis using a paired t-test showed that the combination of deep breathing and incentive spirometry has a significant effect on oxygen saturation, with a delta value of 4.55 and an average value of 99.00, which means that the average oxygen saturation value of patients is 99%, which is in the high category.

The results of the inferential analysis using a paired t-test showed that the combination of deep breathing and incentive spirometry had a significant effect on peak expiratory flow, with a delta value of 130.27 and an average value of 455.36, suggesting that the patients' average peak expiratory flow after the intervention was within the high category.

DISCUSSION

The present study demonstrated that both deep breathing exercise (DBE) and incentive spirometry (IS) effectively improved oxygen saturation and peak expiratory flow rate (PEFR) among post-extubation ICU patients, with the combined intervention showing the most significant improvement. These findings highlight the importance of structured respiratory rehabilitation in preventing post-extubation respiratory failure and facilitating physiological recovery.

From a theoretical perspective, these findings can be interpreted through Orem's Self-Care Deficit Nursing Theory, which emphasizes the patient's active role in self-care to maintain or restore health (Hartweg & Metcalfe, 2022; Yip, 2021). Following extubation, patients often experience respiratory muscle weakness and reduced pulmonary compliance, which may hinder spontaneous breathing. Guided breathing exercises such as DBE and IS encourage patient participation in their own recovery, enhancing self-efficacy and promoting respiratory independence. In this context, nurse's role extends beyond clinical observation to include education, motivation, and facilitation of patient self-care-aligning with Orem's concept of supportive-educative nursing systems.

In addition, the findings can be conceptually linked to Roy's Adaptation Model, which views individuals as adaptive systems responding to environmental stimuli. Post-extubation breathing challenges represent focal stimuli, while DBE and IS interventions serve as regulator mechanisms facilitating physiological adaptation. Improvements in oxygen saturation and PEFR reflect enhanced adaptation through better alveolar recruitment, increased tidal volume, and strengthened respiratory muscle performance. This adaptive response indicates that nursing interventions promoting active respiratory engagement can effectively support homeostatic recovery in critically ill patients.

Physiologically, these results may be explained by improved alveolar recruitment and the prevention of atelectasis due to sustained maximal inspiration during IS use. Deep breathing exercises enhance diaphragmatic excursion, allowing for greater alveolar expansion and improved gas exchange efficiency. When combined, these two techniques provide both cognitive feedback (via IS) and muscular conditioning (via DBE), producing a synergistic effect on lung ventilation and oxygen diffusion.

Our findings are consistent with prior studies demonstrating significant increase in oxygen saturation and lung function following DBE and IS interventions (Katare & Chicholikar, 2020; Ahmed & Dawood, 2024; Joshi & Singh, 2023). Similarly, Bastamizad et al. (2023) and Zeng et al. (2023) reported enhanced PEFR and oxygenation following incentive spirometry training. However, discrepancies with studies reporting limited benefits (e.g., Jenkins et al.) may stem from differences in patient populations, post-extubation timing, or adherence to intervention protocols. Such variation underscores the importance of standardizing the frequency, duration, and supervision of respiratory exercises in ICU settings.

From a clinical standpoint, the combination of DBE and IS aligns closely with the nursing role in critical care-particularly in patient education, monitoring, and facilitating self-care behaviors. Nurses play a central role in ensuring correct technique, assessing patient tolerance, and motivating adherence to breathing regimens. Nurses play a central role in ensuring correct technique, assessing patient tolerance, and motivating adherence to breathing regimens. Implementing these exercises as part of routine post-extubation care could reduce reintubation rates, improve oxygenation stability, and shorten ICU stay durations. Integrating DBE and IS protocols into standard nursing care plans may also promote continuity of care and support evidence-based respiratory rehabilitation practices.

Overall, the findings of this study emphasize that nursing-led respiratory interventions grounded in theory and physiology can significantly enhance post-extubation outcomes. Future studies should further explore behavioral components influencing patient compliance and the long-term impact of combined respiratory exercises on functional recovery and quality of life.

CONCLUSION

Deep breathing exercise and incentive spirometry are effective in improving oxygen saturation and PEFR in post-extubation ICU patients. The combination of both interventions yields the most significant improvement. These findings support the incorporation of DBE and IS as supportive interventions in post-extubation care. Larger randomized controlled trials are needed to confirm these results.

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