Effect of Preoperative Therapeutic Exercises Education Program on Clinical Outcomes of Patients Undergoing Cardiothoracic Surgery

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Abstract

Background: Cardiothoracic surgery (CTs) is a cornerstone for treating a variety of cardiovascular and respiratory disorders, and despite its potential to save lives, usually incorporates fatal complications. Postoperative therapeutic exercises are a key intervention for the avoidance or thorough management of these complications. The quality of preoperative health education given to patients can impact their outcomes. Thus, patients' educational programs lay the groundwork for better outcomes and fewer postoperative problems. **Study aim***:* Evaluate effect of preoperative therapeutic exercises education program on clinical outcomes of patients undergoing CTs. **Design:** a quasi-experimental design. **Setting:** Cardiothoracic surgery departments of Cardio-Thoracic Hospital at Zagazig University Hospitals, Alsharqia governorate, Egypt. **Subject:** A purposive sample of 60 patients who are undergoing CTs. **Tools:** Patients' assessment interview questionnaire, therapeutic exercises observational checklist, and clinical outcomes assessment system. ***Results:*** There was a highly statistically significant improvement and difference between the study and control group patients in terms of knowledge, practice, and clinical outcomes. The study group patients had higher levels of overall knowledge and practice regarding CTs postoperative therapeutic exercises (80.0% and 86.7%, respectively) than the control group (46.7% and 43.3%); in addition to having normal or better clinical outcomes of circulatory, respiratory, wound status, and pain level compared to the control group. **Conclusions:** The preoperative therapeutic exercises education program is considered an effective nursing strategy for enhancing the clinical outcomes of patients undergoing CTs as it significantly improved the patients' knowledge and practice of cardiothoracic postoperative exercises that in turn improved their clinical outcomes, which reflects its positive effect on patients' outcomes. **Recommendations***:* There should be widespread implementation of the preoperative therapeutic exercises education program in study settings and all comparable ones, including all government hospitals.

Keywords: Cardiothoracic surgery, Clinical outcomes, Therapeutic exercises educational program.

Introduction:

Cardiothoracic surgery (CTs) is the most difficult and demanding of all the surgeries that can save lives and enhance quality of life (QoL). Since the end of World War II, cardiothoracic surgery has grown rapidly and seen remarkable technological advancements **(Prerana Sarma et al., 2021)**. The organs of the chest, including the heart, lungs, esophagus, trachea, pleura, mediastinum, chest wall, and diaphragm, are the focus of cardiothoracic surgery. Even though technological advancements have made these complex surgical operations safer and more accessible, there is a considerable chance of serious complications **(Jänne et al., 2022)**.

The most crucial time for patients having CTs is the post-operative phase, when they face the risk of experiencing problems following the surgery **(Adekola, 2016)**. Pulmonary complications continue to be a significant contributor to postoperative morbidity and death, which raises expenses and lengthens hospital stays for patients having CTs **(Stephens, 2013)**. To speed up the restoration of functional status, exercise therapy following CTs is typically utilized for the prevention and/or treatment of postoperative complications, particularly pulmonary and motor problems **(Hoogeboom et al., 2014)**.

Postoperative exercises are the primary strategy for preventing or fully managing acute or long-term surgical problems. Cardiothoracic

patients in a hospital setting are required to complete the following immediate postoperative therapeutic exercises: deep breathing exercises, coughing with splinting, incentive spirometry, arm stretches, shoulders and wrist rotation exercises, leg exercises, turning, walking, and stair climbing exercises to regain their cardiorespiratory fitness; the patient can perform these exercises for four to six hours or as soon as they are disconnected from the mechanical ventilator **(Honnalli & Hadapad, 2024)**.

An increasing number of studies emphasized the importance of performing postoperative therapeutic exercises after CTs as a cost-effective technique with major benefits and minor problems. The postoperative therapeutic exercises are necessary to decrease postoperative complications and facilitate recovery, aiming to improve the cardiorespiratory condition through improved cardiac output, venous return, myocardial contractility, symptoms, cardiac muscle strength, and QoL, as well as increase functional residual capacities, improve alveolar ventilation, lower work of breathing, establish diaphragmatic excursion, and improve quality of respiration. Even so, these health benefits are associated with lower hospitalization and mortality rates **(Hosseinpour et al., 2024; Hayashi et al., 2016)**.

Preoperative health education is an essential part of the patient's surgical experience, as the primary responsibility of nurses is to prepare patients for surgery by providing health-related information about post-surgical activities **(Singh, 2024)**. According to numerous studies, preoperative education can dramatically lower the risk of postoperative complications and length of hospital stays, as the incidence of postoperative complications is particularly high among patients having significant surgery in developing nations, while in Western countries, the percentage of such complications is significantly lower due to the high quality of preoperative education **(Honnalli & Hadapad, 2024)**. Also, obtaining education has a favorable impact on patients' exercise-performing status, as there is a substantial positive link between education and postoperative therapeutic exercise (**Ünver et al., 2018)**.

Furthermore, health educational sessions in the preoperative period assist the patient in comprehending the postoperative procedures and the necessity of performing postoperative exercise effectively in spite of incisional pain to achieve positive outcomes postoperatively **(Elgazzar et al., 2023)**. So, patients with a variety of cardiovascular and respiratory conditions that may necessitate cardiothoracic can benefit from exercise education programs, which are considered a key element of their rehabilitation regimen **(Hosseinpour et al., 2024)**. Thus, in order to improve clinical outcomes and the physical capacity of patients following CTs, educational programs are recommended **(Xue et al., 2022)**.

Significance of the study:

Cardiothoracic surgery accounts for 38% of all surgeries performed worldwide and are the third leading cause of death. Every year around one million new cases and 500 thousand deaths result from CTs discovered over the world. CTs in Egypt were 2.91% in males and 2.31% in females per 100,000 populations. Approximately 39% of CT patients will have advanced disease, with 19% being detected with late consequences (**Abass et al., 2020; Dolatkhah et al., 2018)**. Patients who have CTs are especially vulnerable to postoperative complications since there is a significant gap in their knowledge and practice of postoperative exercises **(Honnalli & Hadapad, 2024)**. So, the thorough health education program for CTs postoperative therapeutic activities lays the groundwork for avoiding problems as well as enhancing patient outcomes **(Elgazzar et al., 2023)**.

Aim of the study:

The current study aimed to evaluate the effect of a preoperative therapeutic exercises education program on the clinical outcomes of patients undergoing cardiothoracic surgery through the following:

- Assess the level of knowledge and practice regarding postoperative therapeutic exercises as well as clinical outcomes of patients undergoing CTs.
- Design and implement a preoperative therapeutic exercises education program for patients undergoing CTs based on previously explored actual needs.

- Evaluate the effect of the preoperative therapeutic exercises education program on the knowledge and practice regarding postoperative therapeutic exercises as well as the clinical outcomes of patients undergoing CTs.

Research hypotheses:

The following research hypotheses were created to reach the study's objective:

- **H_1:** Following the intervention of a preoperative therapeutic exercises education program, the study group patients' level of knowledge and practice of cardiothoracic postoperative therapeutic exercises will differ from that of the control group and improve significantly.
- **H_2:** The clinical outcomes of patients in the study group following the intervention of a preoperative therapeutic exercises education program will differ significantly from those of the control group.
- **H_3:** There will be a significant correlation between the clinical outcomes of patients undergoing CTs and their knowledge as well as the practice of postoperative therapeutic exercises.

Subjects and Methods:

Research Design:

A quasi-experimental research design was utilized to conduct the study, which involved two groups (study and control) with pre- and post-intervention testing. A cause-and-effect relationship between the independent and dependent variables is investigated using the quasi-experimental study approach. The dependent variable is the one that is impacted, whereas the independent variable is the one that is influencing **(Loewen & Plonsky, 2016)**.

Setting:

The present study was conducted in the cardiothoracic surgery departments (males and females wards) of the Cardio-Thoracic Hospital at Zagazig University Hospitals, which is composed of an open-heart ICU that contains 12 beds and cardiothoracic surgery wards that consist of 56 beds.

Subjects:

A purposive sample of 60 patients who were undergoing cardiothoracic surgery in the aforementioned setting and fulfilled the following inclusion requirements: Male and female adults eighteen years of age and older who are willing to engage and do not have any mental or cognitive impairments. While the exclusion criteria were patients with unstable hemodynamic conditions (such as unconscious patients, uncontrolled hypertension, significant arrhythmias, and significant renal and hepatic failure), conditions that could limit exercise (e.g., Parkinson's disease and the presence of artificial joints), and those with visual, hearing, and behavioural issues that would disable them from safely completing the requirements of the study.

Sample size:

The sample size was 60 patients to achieve a power of 80% and a level of significance of 5% (two-sided), assuming the standard deviation of the differences to be 2.500 between pairs. The sample size was calculated based on the following equation:

$$n = \frac{(z\alpha|2+z\beta)\text{^}2\times 2(SD)\text{^}2}{d\text{^}2}$$

SD = standard deviation obtained from previous study; Zα/2, for 5% this is 1.96; Zβ, for 80% this is 0.84 and d, for the expected difference. Based on the above formula, the sample size was 60 patients who were split into two equal groups at random: the study group (30 patients) consisted of patients who received the preoperative therapeutic exercises education program in addition to the standard nursing staff care, and the control group (30 patients) consisted of patients who received standard nursing staff care without any extra interventions.

Tools of data collection:

Tool I: Patient's assessment interview questionnaire:

The researchers adapted it from **Vanmathi (2015)** to assess patients' knowledge of therapeutic exercises following cardiothoracic surgery and then modified it following a thorough study of relevant literature **(Honnalli & Hadapad, 2024; Raghavendran, 2019;**

Rahul & Reddy, 2017). It was separated into three primary sections, which are as follows:

- **Section I**: **Patient's demographic characteristics**: Ten items of the patients' personal demographic information were covered in this section, including age, gender, marital status, education level, place of residency, occupation, monthly income, smoking, life status, and family support.
- **Section II: Patient's knowledge assessment questionnaire:** This section was designed to evaluate the patients' knowledge regarding cardiothoracic postoperative therapeutic exercises. It has thirty items that are separated into two knowledge categories as follows:

  A. *The first section* addressed the patients' knowledge about cardiothoracic postoperative therapeutic exercises, which integrated "20 items," including the definition and purpose of postoperative therapeutic exercises, the exercises to be performed right after recovery, the comfortable position to perform deep breathing exercises, the appropriate time to perform deep breathing exercises, the purpose of using breathing devices in CTs, the number of balls elevated during using breathing devices, the meaning of breathing exercises, the precautions to be taken during coughing exercises, the meaning of arm exercises and the purpose of performing them after CTs, the circumstances in which arm exercises should be avoided, the meaning of shoulder rotation exercise, the exercise that prevents shoulder stiffness, the meaning of wrist circle exercises, the goal and advantage of elbow flexion exercises, the benefits of turning exercises in bed following surgery, the situations that prevent post-operative mobilization, and the benefits of walking exercises.

  B. The second section integrated 10 items that addressed the patient's knowledge about the potential complications of cardiothoracic surgery as a general, the complications that may arise if post-operative therapeutic exercises are not performed (such as wrist rotation exercises, breathing exercises, leg exercises, shoulder exercises, coughing exercises), and preventive measures of cardiothoracic surgery complications.

- ***Knowledge scoring system:*** Each item had four possible answers and was a multiple-choice question. Each right answer received a score of one, whereas a wrong answer received a score of zero. Each knowledge area's mean score was calculated by adding up all of the item scores, dividing the total by the number of items, and then summarizing the results. Then, these average ratings were converted to percentage scores. It was found through data entry and statistical analysis that knowledge scores of 60% or above were considered satisfactory, while scores below 60% were considered unsatisfactory.

Tool II: Therapeutic exercises observational checklist:

This tool was adopted from **Craven & Hirnle (2009) and Wilkinson & Van (2007)** to assess patients' practice of various cardiothoracic postoperative therapeutic exercises. It included 48 items covering 10 main postoperative therapeutic exercises such as deep breathing exercises (5 steps), incentive spirometry (6 steps), coughing exercise with splinting (5 steps), arms stretch exercise (4 steps), shoulders rotation (6 steps), wrist rotation (3 steps), turning exercise (6 steps), leg exercise (6 steps), walking exercise (4 steps), and stair climbing exercise (3 steps).

- ***Practice scoring system:*** "one" was assigned to each practice item that was observed to be done correctly, and a score of "zero" to those that were not. The total number of items divided by the sum of the item scores yielded the mean score for each practice area. These scores were calculated as percentages. Data entry and statistical analysis were used to determine if a practice was considered satisfactory if its percent score was ≥60% and unsatisfactory if it was less than 60%.

Tool III: Clinical Outcomes Assessment System:

To evaluate the clinical outcomes of cardiothoracic patients postoperatively, researchers adapted this tool from **Maarouf & Ameen (2021)** following a thorough study of relevant literature **(Abdelkader, 2024; Wang et al., 2023; Shahood et al., 2022)**. It consisted of 37 items covering the five primary domains of postoperative assessment: circulatory status (6 items), respiratory status (22 items included gas exchange & ventilation), wound status (5 items), and pain level (4 items). The pain scale was a numerical rating system with a total score of eleven points, with zero being no pain, one to three being mild, five to six being moderate, and seven to ten being severe pain **(Mc Caffery & Beebe, 1993)**.

Preoperative therapeutic exercises education program:

Based on the patient's needs, which were identified during the assessment phase, the researchers developed it. Its goal was to improve the clinical outcomes of study group patients getting CTs by enhancing their knowledge and practice regarding cardiothoracic postoperative therapeutic exercises. It is designed to be used as a booklet about cardiothoracic postoperative therapeutic exercises, and it is written in plain Arabic. Expert viewpoints and an assessment of relevant literature, such as nursing textbooks, journals, and internet resources, form its foundation. The knowledge, practice, and clinical outcomes of patients were assessed before (pre-phase) and after (post-phase) program intervention, then results were compared between the two groups under study in order to assess the effect of the preoperative therapeutic exercises education program.

Tools validity and reliability:

A panel of three specialists, comprising one professor of cardiothoracic surgery from Zagazig University Hospitals and two medical-surgical nursing professors from the nursing college, evaluated the instruments' face and content validity once they were ready. These experts evaluated the tools' suitability, comprehensiveness, understandability, and ease of use. Small changes were made based on the advice of the experts. The internal consistency and reliability of each tool item were assessed using a Cronbach's alpha test; the patients' knowledge tool score was 0.74, their practice tool score was 0.83, and their clinical outcomes tool score was 0.85.

Ethical consideration:

In addition to formal consent from the directors of the aforementioned study places, the ethics committee and the dean of Zagazig University's nursing faculty gave their approval before the study started. As well, an oral agreement was sought from participating patients before data collection in order to ensure maximum cooperation and to arrange for their presence. The purpose, methodology, and nature of the study were explained to these patients. The participants were also informed that they could decline to continue with the study at any time. All of the patients were guaranteed that their information would only be used for research reasons, and absolute confidentiality was upheld throughout the study.

Pilot study:

Ten percent (six patients) of the primary study sample were used to test the instruments' comprehensiveness, clarity, relevance, comprehension, application, and ease of use. The time required to complete the forms was also estimated with the aid of the pilot study. Patients who took part in the pilot study were included in the formal study sample because no changes were made to the instruments.

Fieldwork:

After obtaining all required official clearances, the study was carried out in the following order:

(1) Assessment phase:

- Data collected for this study took place between early July 2023 and December 2023. Over the course of six months, the preoperative therapeutic exercises education program took place. Prior to performing the study, the researchers secured the necessary official approval from the dean of the faculty of nursing at Zagazig University and the director of Zagazig University hospitals during the assessment phase. Following that,

researchers went to the study setting and met with the directors and head nurses to explain the purpose and methods of the study to get their consent and cooperation. They then met with the patients who fulfilled the eligibility requirements and had already been admitted to the hospital for surgery, informed them of their rights, and invited them to participate.

- Patients who consented to participate in the study were randomized to either the control group or the study. A pre-operative baseline assessment was done for each patient in both groups at the beginning of the study, as each patient was interviewed separately using the designed data collection tools. From 30 to 35 minutes were needed to finish the data collection tools. The interviews were conducted during the morning and afternoon shifts on Saturday, Monday, and Wednesday, three days a week, in accordance with the surgical list.

(2) The planning phase:

- In this phase, the researchers create the therapeutic exercises education program and its booklet about cardiothoracic postoperative exercises in the Arabic language based on the patients' previously determined needs, a review of the most current and pertinent literature, and expert opinions. The main goal of program and its booklet was to apply postoperative therapeutic exercises after CTs in order to improve their clinical outcomes. The program's content was created with this overarching goal in mind, along with particular goals which addressed the requirements of the patients that determined during the assessment phase. It was divided into the following two major parts:
  - *The theoretical part*, which provides to patients detailed knowledge about cardiothoracic surgery (Brief about CTs, indications, preoperative procedures, procedures on the day of surgery, and postoperative procedures, complications, discharge recommendations, and lifestyle changes) and cardiothoracic postoperative therapeutic exercises (Brief about therapeutic exercises, its benefits, types, precautions to be considered when doing these exercises, contraindications, and when to stop).
  - *The practical part* involved training of patients in performing cardiothoracic postoperative therapeutic exercises, which included deep breathing exercises, incentive spirometry, coughing exercises, arm stretch exercises, shoulder rotation, wrist rotation, turning exercises, leg exercises, walking exercises, and stair climbing exercises.

(3) The implementation phase:

- The developed program was implemented in the form of educational sessions carried out in the study settings for the study group patients within their period of hospitalization. The researchers conducted the therapeutic exercises education program over "9" educational sessions, most of which were carried out preoperatively, with three sessions for the theoretical part and six sessions for the practical part, as follows: *The first session* was to clarify the aim, contents, objectives, teaching methods of the program, and patients' evaluation methods, as well as an explanation of the educational booklet that was given to each patient in the study group. *The second and third sessions* of the program's theoretical part covered detailed information about cardiothoracic surgery and its postoperative therapeutic exercises. Whereas, *the remaining six sessions* were for the practical part, which included three sessions applied preoperatively for demonstration and re-demonstration of the cardiothoracic postoperative therapeutic exercises that were mentioned before, and three sessions for also re-demonstration and reinforcement of these exercises application following the surgery. Each theoretical session lasted 30 to 35 minutes, while the practical sessions lasted 45 to 60 minutes. These sessions were held during the morning and afternoon shifts; the night shift was skipped to give the patients time to rest and sleep.
- In order to grab patients' attention and encourage their participation, the researchers used a variety of learning techniques in training, including presentations, lectures, and discussions, in addition to a variety of

educational materials, including videos, coloured handouts, brochures, and posters. Each patient in the study group also received the educational booklet at the beginning of the program. In contrast to the study group, the control group did not get any extra interventions from the researchers during the program's implementation; instead, they received their regular nursing staff care.

(4) The evaluation phase:

- For the purpose of evaluating the effect of the preoperative therapeutic exercises education program on patients undergoing CTs, the studied patients' knowledge, practice, and clinical status were evaluated after (post-phase) the program's intervention using the same data collection tools as the pre-test. The program's effectiveness was assessed by looking at whether there were any changes or differences between the two groups. When the evaluation phase finished, the researchers were given the educational booklet of postoperative therapeutic exercises to control group patients to benefit from it.

Statistical design:

After the data-gathering process was finished, the Statistical Package for the Social Sciences (SPSS), version 26, was used to compute and analyze the data. The findings were described using descriptive statistics tests as numbers, percentages, and mean ± standard deviation (mean ± SD). The relationship between the qualitative data groups was ascertained using appropriate inferential statistics, such as the Chi-square test "χ^2." The study and control groups' mean scores were compared using an independent t-test, and the study group's knowledge, practice, and clinical outcomes correlation were assessed using a correlation coefficient. Additionally, the study group's clinical outcome predictors were evaluated using the multi-regression test. The P value was highly significant at <0.001** and significant at 0.05.

Results:

Table 1 illustrates that the highest percentage (60.0% & 50.0%, respectively) of patients in study and control groups are females and more than 40 years of age, with a mean age of 46.59±4.56 and 47.65±6.35, respectively. Also, 43.3% and 60.0%, respectively, of the study and control groups are married. As regards education level and residence, the highest percentage (40.0% and 56.7%, respectively) of the study group had a university education and resided in urban areas, while 43.3% and 56.7%, respectively, of the control group had secondary education and resided in rural areas. In addition, 66.7% & 56.7%, respectively, of study and control groups patients were working, but their monthly income was not enough (53.3% & 73.3%, respectively). Furthermore, 56.7% of study group patients were no smokers, while 53.3 percent of the control group were smokers. Moreover, 63.3 & 66.7, respectively, of the study and control groups lived with family, and 63.3 & 73.3, respectively, of them had family support.

Table 2 indicates that there are no statistically significant differences between the study and control groups' knowledge domains during the pre-intervention phase ($p > 0.05$) of the preoperative therapeutic exercises education program about cardiothoracic post-operative exercises and CTs complications that may arise if post-operative exercises are not performed. While there is a highly statistically significant improvement and difference in knowledge domains between the two groups at the program's post-intervention phase ($p<0.001$), as the study group patients' total mean score (21.6667±4.25346) for knowledge domains is higher than that of the control group (15.3000±2.32156), and the improvement is more obvious among study group patients at the post-program phase than it was at the pre-program phase compared to the control group, as it rose from 13.3333±2.92826 at the pre-program phase to 21.6667±4.25346 at the post-program phase while the control group rose from 13.0333±3.34750 to 15.3000±2.32156.

Figure 1 illustrates that at the pre-intervention phase of the preoperative therapeutic exercises education program, the highest percentages (90.0% & 80.0%, respectively) of both the study and control group patients had unsatisfactory overall knowledge level regarding cardiothoracic post-operative exercises, while at the post-

intervention phase, 80.0% of the study group became had a satisfactory level of overall knowledge, whereas 46.7% only of the control group had a satisfactory level of knowledge. Although the overall knowledge score of both groups was improved, the study group's overall satisfactory knowledge score showed more obvious improvement in the post-intervention phases of the program than in the pre-program phase compared to the control group, as it rose from 10.0% in the pre-intervention phase to 80.0% at the post-intervention phase of the program while the control group rose from 20.0% to 46.7%.

Table 3 indicates that there was no statistically significant difference ($p > 0.05$) between the study and control groups' practice domains during the pre-intervention phase of the preoperative therapeutic exercises education program in their practice for cardiothoracic post-operative exercises, such as deep breathing, incentive spirometry, coughing, arm stretching, turning, leg, walking, and stair climbing exercise. While there is a highly statistically significant improvement and difference ($p<0.001$) in practice domains between the two groups at the program's post-intervention phase, as the study group patients' total mean score (38.3333±4.91538) for practice domains is higher than that of the control group (17.4333±11.94436), and the improvement is more obvious among study group patients at the post-program phase than it was at the pre-program phase compared to control group, as it rose from.5667±.89763 at the pre-program phase to 38.3333±4.91538 at the post-program phase while control group rose from.8333±.79148 to 17.4333±11.94436.

Figure 2 illustrates that 76.7% and 70.0%, respectively, of the studied patients in both the study and control groups had an unsatisfactory overall practice level for cardiothoracic postoperative exercises at the pre-intervention phase of the preoperative therapeutic exercises education program, while at the post-intervention phase, 86.7% of the study group had a satisfactory level of overall practice for cardiothoracic postoperative exercises, whereas 43.3% only of the control group had a satisfactory overall practice level. Although the overall practice score of both groups was improved, the study group's overall satisfactory practice score showed more obvious improvement in the post-intervention phases of the program than in the pre-program phase compared to the control group, as it rose from 23.3% in the pre-intervention phase to 86.7% at the post-intervention phase while the control group rose from 30.0% to 43.3%.

Table 4 indicates that totally, all the circulatory status clinical outcomes showed statistically significant improvement and differences between the study and control group in a post-intervention phase of the preoperative therapeutic exercises education program, as the highest percentage of patients in the study group had circulatory status normal clinical outcomes compared to the control group and there is a highly statistical significant difference ($p<0.001$) between study and control group patients in clinical outcomes of circulatory status post-program as the majority of study group patients (86.7% and 83.3% respectively) hadn't extreme fatigue and their pulse pressure in expected range (IER); also more than three quarters (76.7%) of them their systolic blood pressure and peripheral tissue perfusion IER. In addition, there is a statistically significant difference ($p<0.05$*) between the study and control groups in other circulatory status clinical outcomes parameters, as 80.0% and 76.3%, respectively, of study group patients heart rate and diastolic blood pressure IER.

Table 5 reveals that generally, all the gas exchange clinical outcomes parameters showed statistically significant improvement and differences between the study and control group at the post-intervention phase of the preoperative therapeutic exercises education program, as the highest percentage of patients in the study group had gas exchange normal clinical outcomes compared to control group as well there is a highly statistically significant difference ($p<0.001$) between study and control group patients in clinical outcomes of gas exchange post-program as 86.7% of study group patients hadn't dyspnea at rest; 80.0% of them hadn't dyspnea with exertion, cyanosis, and somnolence as well as their arterial pH within normal range and O_2 saturation 95%; 76.7% their PaO_2 & $PaCo_2$ within normal range. Furthermore, there is a statistically significant difference ($p<0.05$) between the

study and control group in other gas exchange clinical outcomes parameters, as 86.7%, 83.3%, 80.0%, and 73.3%, respectively, of them had normal mental status, hadn't restlessness, had ease of breathing, and their chest X-ray finding is normal.

Table 6 demonstrates that totally, all the ventilation clinical outcomes showed statistically significant improvement and differences between the study and control group in a post-intervention phase of the preoperative therapeutic exercises education program, as the highest percentage of patients in the study group had ventilation normal clinical outcomes compared to a control group, and there is a highly statistically significant difference ($p<0.001$) between study and control group patients in clinical outcomes of respiratory status that associated with ventilation as 86.7 of study group patients hadn't chest retraction and their PFT using spirometer in expected range; 80.0% of them chest expansion symmetrically, hadn't adventitious breath sounds and the auscultated breath sound is normal; 76.7 of them their percussed sounds is normal. Additionally, there is a statistically significant difference ($p<0.05$) between the study and control groups in other ventilation clinical outcomes parameters, as 86.7 of the study group patients had their respiratory rate and rhythm IER and hadn't orthopnea; 83.3% vocalized adequately, didn't use accessory muscles and didn't have shortness of breath.

Table 7 indicates that there is a highly statistically significant improvement and difference ($p<0.001$) between study and control group patients in all items of wound status clinical outcomes at the post-intervention phase of the preoperative therapeutic exercises education program, as 90.0%, 80.0%, and 76.7%, respectively, of patients in the study group's wound culture is negative, they haven't had WBC elevation, and they hadn't had foul-smelling discharge. In addition, there is statistically significant improvement and difference ($p<0.05$) between study and control group patients in other wound status clinical outcomes, as 83.3% and 76.7%, respectively, hadn't purulent drainage and pain/tenderness at the wound site ($p<0.05$).

Regarding the pain level clinical outcomes, **Table 8** shows that there is a highly statistically significant improvement and difference ($p<0.001$) between study and control group patients at the post-intervention phase of the preoperative therapeutic exercises education program, as the study group's lowest percentage (6.7%) of patients experienced severe pain, with 13.3% reporting no pain, while the control group's highest percentage (46.7%) of patients experienced severe pain, with none of them reporting no pain.

Table 9 shows a highly statistically significant positive correlation between the study group patients' clinical outcomes and their overall knowledge ($p =.003$) and practice score ($p =.001$) at the post-intervention phase of the preoperative therapeutic exercises education program and vice versa. This means that improving patients' knowledge about cardiothoracic postoperative therapeutic exercises and their adherence to practicing these exercises will enhance or reflect on their clinical outcomes. Also, there was a highly statistically significant positive correlation between study group patients' knowledge and practice ($p =.000$) and vice versa.

Table 10 indicated that the main statistically significant positive predictor of the study group patients' clinical outcomes is their practice of cardiothoracic postoperative therapeutic exercises since the highest clinical outcomes are linked to high levels of practice for these exercises ($t = 2.331$ and $p =.032*$). However, none of the other patients' variables had a significant effect on the clinical outcomes score. The model demonstrates 71% of the variation in the clinical outcomes scores following program intervention, based on the r-square value.

Table (1): Frequency and Percentage Distribution of Demographic Characteristics for Patients in the Study and Control Groups (n = 60):

Demographic characteristics	Study group (n=30)		Control group (n=30)		χ^2	p-value
	No.	%	No.	%		
Age per years:						
- 20-<35	5	16.7	5	16.7	1.29	> 0.05
- 35-<50	16	53.3	12	40.0		
- 50-60	9	30.0	13	43.3		
Mean ±SD	*46.59±4.56*		*47.65±6.35*			
Gender:						
- Male	12	40.0	15	50.0	0.606	> 0.05
- Female	18	60.0	15	50.0		
Marital status:						
- Single	2	6.7	3	10.0	3.57	> 0.05
- Married	13	43.3	18	60.0		
- Divorced	10	33.3	4	13.3		
- Widow	5	16.7	5	16.7		
Educational level:						
- Illiterate	3	10.0	4	13.3	1.33	> 0.05
- Read & write	5	16.7	8	26.7		
- Secondary	10	33.3	13	43.3		
- University	12	40.0	5	16.7		
Place of Residency:						
- Rural	13	43.3	17	56.7	1.06	> 0.05
- Urban	17	56.7	13	43.3		
Occupation:						
- Work	20	66.7	17	56.7	0.635	> 0.05
- Not work	10	33.3	13	43.3		
Monthly income:						
- Enough	14	46.7	8	26.7	2.58	> 0.05
- Not enough	16	53.3	22	73.3		
Smoking:						
- Yes	13	43.3	16	53.3	0.601	> 0.05
- No	17	56.7	14	46.7		
Life Status:						
- Alone	11	36.7	10	33.3	0.073	> 0.05
- With family	19	63.3	20	66.7		
Family support:						
- Yes	19	63.3	22	73.3	0.693	> 0.05
- No	11	36.7	8	26.7		

χ^2: Chi-square test ***Insignificant (p>0.05).***

Table (2): Knowledge Domains Mean Scores about Cardiothoracic Postoperative Exercises among Study and Control Group Patients throughout Preoperative Therapeutic Exercises Education Program Intervention Phases (n = 60):

Exercises Program Phases	Patients' Knowledge Domains	Study group (n=30)	Control group (n=30)	Paired t-test	p-value
		Mean±SD	Mean±SD		
Pre-intervention phase	Knowledge about cardiothoracic post-operative exercises.	7.9000±1.49366	8.533±2.01260	1.38	> 0.05
	Knowledge about cardiothoracic surgery complications.	5.43±2.128	4.50±2.162	1.68	> 0.05
	Pre total knowledge domains mean scores	***13.3333±2.92826***	***13.0333±3.34750***	0.369	***> 0.05***
Post-intervention phase	Knowledge about cardiothoracic post-operative exercises.	14.0333±3.81000	9.6667±1.58296	5.79	<0.001**
	Knowledge about cardiothoracic surgery complications.	7.6333±.96431	5.6333±1.29943	6.77	<0.001**
	Post total knowledge domains mean scores	***21.6667±4.25346***	***15.3000±2.32156***	7.19	***<0.001****

Paired t-test was used; ***** Statistically highly significant (p<0.001);*** ***Insignificant (p>0.05).***

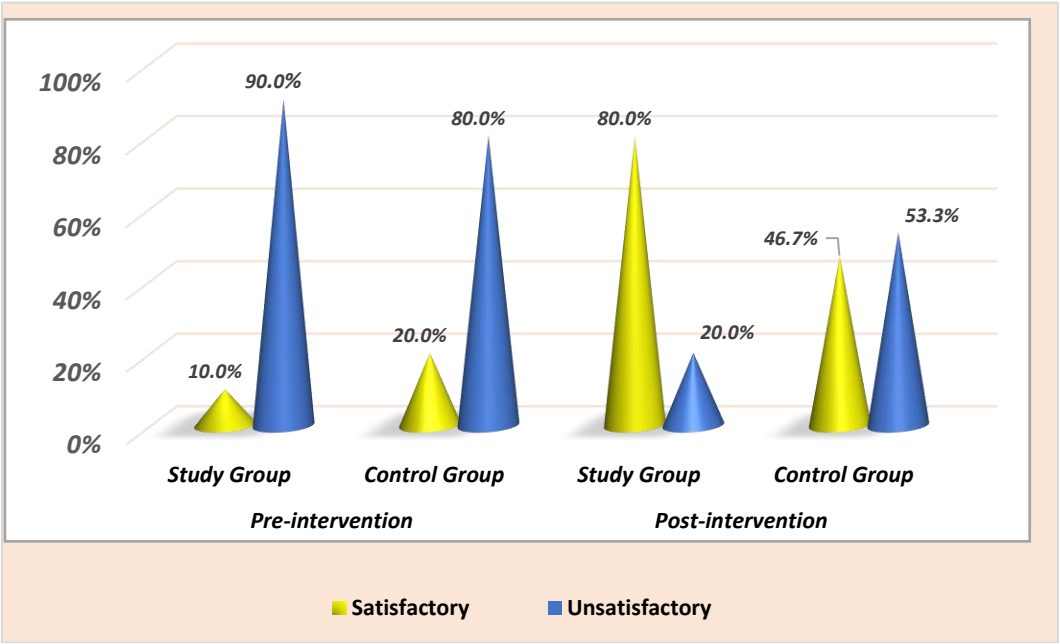

Figure (1): Overall Knowledge Score about CT Post-operative Exercises of Study & Control Group throughout Preoperative Therapeutic Exercises Education Program Phases (n = 60)

Table (3): Practice Domains Mean Scores of Cardiothoracic Post-Operative Exercises among Study and Control Group Patients throughout Preoperative Therapeutic Exercises Education Program Intervention Phases (n = 60):

Exercises Program Phases	Practice Domains	Study group (n=30)	Control group (n=30)	Paired t-test	p-value
		Mean±SD	Mean±SD		
Pre-intervention phase	Deep breathing exercise.	.1000±.30513	.2000±.40684	1.08	> 0.05
	Incentive spirometry.	1.5333±.86037	1.2000±1.44795	1.34	> 0.05
	Coughing exercise.	1.5000±1.07479	1.1333±1.04166	0.773	> 0.05
	Arm stretch exercise.	1.5667±1.63335	1.3000±.95231	0.933	> 0.05
	Shoulders rotation exercise.	1.3333±1.42232	1.6333±1.03335	1.33	> 0.05
	Wrist rotation exercise.	1.7667±1.50134	1.3000±1.17884	0.582	> 0.05
	Turning exercise.	1.0000±1.55364	1.2000±1.06350	0.880	> 0.05
	Leg exercise.	1.2667±1.08066	1.0000±1.25945	1.59	> 0.05
	Walking exercise.	1.7333±.82768	1.3333±1.09334	1.36	> 0.05
	Stair climbing exercise.	.9000±1.09387	.6000±.49827	1.22	> 0.05
	Pre total practice domains mean score	***.5667±.89763***	***.8333±.79148***	1.56	***> 0.05***
Post-intervention phase	Deep breathing exercise.	13.1667±3.54365	11.533±4.47779	17.42	<0.001**
	Incentive spirometry.	4.6000±1.03724	1.5333±1.75643	8.23	<0.001**
	Coughing exercise.	4.5333±1.10589	1.9333±1.83704	6.64	<0.001**
	Arm stretch exercise.	3.6667±.47946	2.5333±2.04658	2.95	<0.001**
	Shoulders rotation exercise.	4.7667±1.30472	2.3333±2.38289	4.90	<0.001**
	Wrist rotation exercise.	2.8000±.40684	2.0000±2.11725	2.03	<0.001**
	Turning exercise.	3.9667±1.12903	1.8000±2.28035	4.66	<0.001**
	Leg exercise.	3.5333±1.19578	1.6667±1.89979	4.55	<0.001**
	Walking exercise.	3.5000±1.00858	1.4000±2.14315	4.85	<0.001**
	Stair climbing exercise.	2.7333±.52083	.9667±1.44993	6.25	<0.001**
	Post total practice domains mean score	***38.3333±4.91538***	***17.4333±11.94436***	8.86	***<0.001****

Paired t-test was used; ***** Statistically highly significant (p<0.001);*** ***Insignificant (p>0.05).***

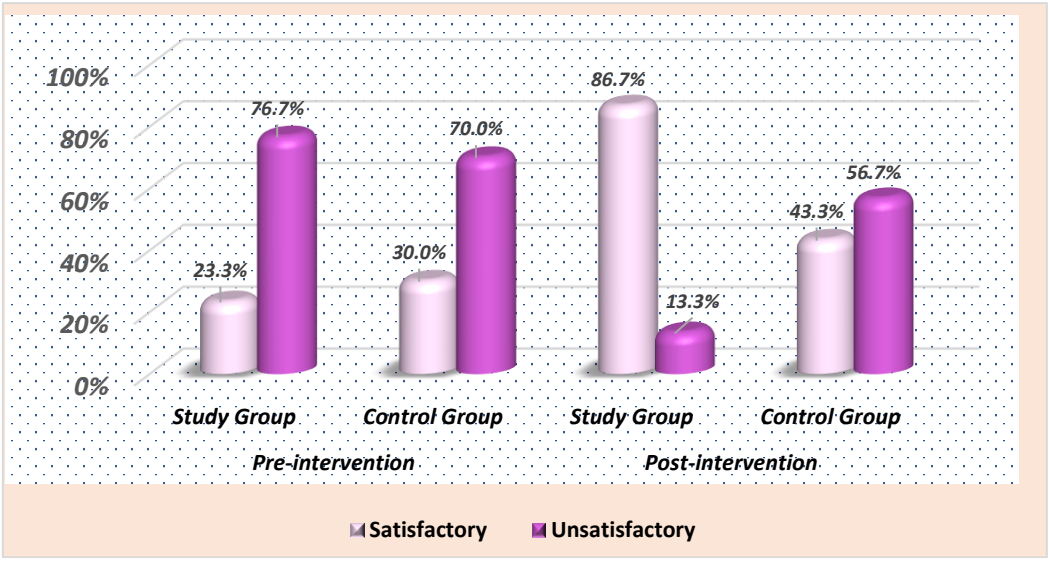

Figure (2): Overall Practice Score for CT Post-operative Exercises among Study & Control Group throughout Preoperative Therapeutic Exercises Education Program (n = 60)

Table (4): Clinical Outcomes of Circulatory Status in Study and Control Group Patients at Post-Intervention Phase of Preoperative Therapeutic Exercises Education Program (n = 60).

Circulatory Status Clinical Outcomes	Study group (n=30)		Control group (n=30)		χ^2	p-value
	No.	%	No.	%		
Systolic blood pressure IER*	23	76.7	12	40.0	8.26	< 0.001**
Diastolic blood pressure IER*	23	76.7	14	46.7	5.71	< 0.05*
Pulse pressure IER*	25	83.3	12	40.0	11.91	< 0.001**
Heart rate (HR) IER*	24	80.0	17	56.7	3.77	< 0.05*
Peripheral tissue perfusion is normal	23	76.7	11	36.7	9.77	< 0.001**
Extreme fatigue not present	26	86.7	11	36.7	15.86	< 0.001**

IER* In Expected Range; ***χ^2: Chi-square test;*** ***** Statistically highly significant (p<0.001);***
**** Statistically significant (p<0.05).***

Table (5): Clinical Outcomes of Respiratory Status that associated with Gas Exchange in Study and Control Group Patients at Post-Intervention Phase of Preoperative Therapeutic Exercises Education Program (n=60).

Respiratory Status Clinical Outcomes	Study group (n=30)		Control group (n=30)		χ^2	p-value
	No.	%	No.	%		
Gas Exchange clinical outcomes:						
Mental status is normal	26	86.7	16	53.3	7.93	< 0.05*
Ease of breathing	24	80.0	14	46.7	7.17	< 0.05*
Dyspnea with exertion not present	24	80.0	13	43.3	8.53	< 0.001**
Dyspnea at rest not present	26	86.7	12	40.0	14.06	< 0.001**
Restlessness not present	25	83.3	15	50.0	7.50	< 0.05*
Cyanosis not present	24	80.0	10	33.3	13.30	< 0.001**
Somnolence not present	24	80.0	11	36.7	11.58	< 0.001**
PaO2 and PaCo2 within normal range	23	76.7	11	36.7	9.77	< 0.001**
Arterial pH within normal range	24	80.0	9	30.0	15.15	< 0.001**
O2 saturation 95%	24	80.0	9	30.0	15.15	< 0.001**
Chest X-ray finding is normal.	22	73.3	14	46.7	4.04	< 0.05*

χ^2: Chi-square test; ***** Statistically highly significant (p<0.001);*** **** Statistically significant (p<0.05).***

Table (6): Clinical Outcomes of Respiratory Status that associated with Ventilation in Study and Control Group Patients at Post-Intervention Phase of Preoperative Therapeutic Exercises Education Program (n = 60).

Respiratory Status Clinical Outcomes	Study group (n=30)		Control group (n=30)		χ^2	p-value
	No.	%	No.	%		
Ventilation clinical outcomes:						
Respiratory rate and rhythm IER*	26	86.7	16	53.3	7.93	< 0.05*
Chest expansion symmetrically	24	80.0	10	33.3	13.30	< 0.001**
Vocalize adequately	25	83.3	15	50.0	7.50	< 0.05*
Accessory muscle use not present	25	83.3	15	50.0	7.50	< 0.05*
Adventitious breath sound not present	24	80.0	9	30.0	15.15	< 0.001**
Chest retraction not present	26	86.7	12	40.0	14.06	< 0.001**
Orthopnea not present	26	86.7	16	53.3	7.93	< 0.05*
Shortness of breath not present	25	83.3	15	50.0	7.50	< 0.05*
Percussed sounds are normal.	23	76.7	11	36.7	9.77	< 0.001**
Auscultated breath sound is normal.	24	80.0	9	30.0	15.15	< 0.001**
Pulmonary function test (PFT) using spirometer IER*	26	86.7	12	40.0	14.06	< 0.001**

IER* In Expected Range; ***χ2: Chi-square test;*** ***** Statistically highly significant (p<0.001);***
**** Statistically significant (p<0.05).***

Table (7): Clinical Outcomes of Wound Status in Study and Control Group Patients at Post-Intervention Phase of Preoperative Therapeutic Exercises Education Program (n=60).

Wound Status Clinical Outcomes	Study group (n=30)		Control group (n=30)		χ^2	p-value
	No.	%	No.	%		
Foul smelling discharge not present.	23	76.7	12	40.0	8.29	< 0.001**
Purulent drainage not present.	25	83.3	18	60.0	4.02	< 0.05*
Pain/tenderness at wound site not present.	23	76.7	14	46.7	5.71	< 0.05*
Wound site culture is negative.	27	90.0	15	50.0	11.42	< 0.001**
WBCs elevation not present.	24	80.0	10	33.3	13.30	< 0.001**

*χ^2: Chi-square test; ** Statistically highly significant (p<0.001); * Statistically significant (p<0.05).*

Table (8): Clinical Outcomes of Pain Level in Study and Control Group Patients at Post-Intervention Phase of Preoperative Therapeutic Exercises Education Program (n=60).

Pain level Clinical Outcomes	Study group (n=30)		Control group (n=30)		χ^2	p-value
	No.	%	No.	%		
No pain	4	13.3	0	0.0	15.10	< 0.001**
Mild pain	9	30.0	3	10.0		
Moderate pain	15	50.0	13	43.3		
Severe pain	2	6.7	14	46.7		

*χ2: Chi-square test; ** Statistically highly significant (p<0.001); * Statistically significant (p<0.05).*

Table (9): Correlation Matrix between Study Group Patients' Overall Clinical Outcomes Score, Knowledge, and Practice at Post-intervention of Preoperative Therapeutic Exercises Education Program (n=60):

Parameters	Test	Clinical outcomes	Knowledge	Practice
Clinical outcomes score	**r**	1	.526**	.562
	p-value		.003	.001**
Knowledge score	**r**	.526	1	.984
	p-value	.003**		.000**
Practice score	**r**	.562	.984	1
	p-value	.001**	.000**	

(r) Correlation coefficient; **. Correlation is significant at the 0.01 level (2-tailed).

Table (10): Best Fitting Multiple Linear Regression Model for the Clinical Outcomes Score among Study Group (n = 70):

Model	Un standardized Coefficients		Standardized Coefficients	t-test	p-value
	B	Std. Error	Beta		
(Constant)	5.683	5.848		.972	.345
Practice	.305	.131	.473	2.331	.032*

****. Statistically highly significant (p<0.001); R=0.846; R-square = 0.71; Adjusted R square = 0.516; ANOVA: F= 3.58**

Variables entered and excluded: age, gender, marital status, education level, residence, occupation, income, smoking, life status, family support, knowledge, and practice.

Discussion:

The third most common surgery performed worldwide is a cardiothoracic procedure, which is associated with advanced age, particularly in the fifties and beyond **(Dolatkhah et al., 2018)**. After multiple surgical procedures, the patient's outcomes evaluation has been demonstrated to have significant predictive relevance **(Alarouri et al., 2023)**. Giving patients information on postoperative exercises prior to surgery not only expedites their recovery and return to regular activities but also makes them feel more comfortable and in less pain. In this way, they improve QoL and raise hospital discharge and recovery rates **(Kalogianni et al., 2019)**. Furthermore, therapeutic exercise-based rehabilitation is advised after CTs and has been shown to benefit patients' functional outcomes and physical capacity in the short term **(Dibben et al., 2021)**.

Education is seen to be the most important factor and a fundamental method for developing the self-management skills required to enhance patients' QoL and health outcomes **(Talboom-Kamp et al., 2017).** So, nurses have a responsibility to teach patients how to manage their postsurgical period after CTs because there is evidence that good education improves the quality of life and reduces anxiety and depression, all of which may have an impact on patients' outcomes and recovery **(Veronovici et al., 2014)**. Therefore, this study aimed to evaluate the effect of a preoperative therapeutic exercises education program on the clinical outcomes of patients undergoing CTs. A discussion of the current results will cover five main areas in the following sequence:

Firstly, the demographic characteristics of studied patients:

Regarding the demographic characteristics of the patients under study, the mean age was 46.59±4.56 for the study group and 47.65±6.35 for the control group. The study group had the highest proportion of patients aged 35–50 years, while the control group's was between the ages of 50 and 60. The study group's lowest proportion of patients was between the ages of 20 and under 35. According to the researchers, this could be because the risk of cardiothoracic disorders rose with age. The present findings are consistent with those of **Elnahal et al., (2022)**, who found that the mean age of the patients at the time of operative intervention was 45.67± 12.27 years in their study "Evaluation of European system for cardiac operative risk (EUROSCORE II) in Egyptian patients."

These findings are similarly in accordance with those of **Abass et al., (2020)**, who reported that the majority mean age of the study and control groups was 46.31 ± 10.28 & 47.57 ± 11.70, respectively, in a study titled "The impact of pre-and postoperative education on recovery period following cardiothoracic surgery." These results also support those of **Gado et al., (2019)**, who found that the majority of the subjects in the study were over 40, with a mean age of 51 ± 15.

In terms of gender, the current study discovered that, whilst control groups had an equal ratio of males and females, the study group was slightly less than two-thirds female. This may be connected, according to the researchers, to the fact that women have particular risk factors for heart conditions, such as those associated with pregnancy, obesity, and autoimmune illnesses. The present findings correspond with the study of **Downing et al., (2019)**, "Health-related quality of life after cardiothoracic surgery in England: a patient-reported outcomes study of individuals 12 to 36 months after diagnosis," which discovered that 113 out of 171 survivors with CTs assessed were of female gender. However, the present findings are incongruous with **Murphy et al., (2017)**, who noted that the proportion of male respondents was almost 30% greater than that of female respondents.

Concerning marital status, the present study showed that the highest percentage of patients in both the study and control groups was married. According to the researchers, this may be explained by the fact that married people experience a lot of stress in their lives from work and family obligations as well as financial overloads, which could have an impact on their physical and mental well-being and result in numerous health issues. This result is in line with the findings of **Said et al., (2022)**, who in their study "Effect of education guidelines on health outcomes and satisfactions

for patients undergoing cardiac surgery" found that the majority of the patients in both groups were married. Furthermore, this result lined up with **Elesawy et al., (2019)**, who demonstrated that most of the patients in both groups under study were married.

The present study revealed that, *in terms of educational level*, the highest proportion of the patients in the study group had a university degree, whereas the patients in the control group only had a secondary education. The current findings concur with those of **Awad et al., (2018)**, who demonstrated in a study titled "Effect of Therapeutic Exercises Program on Patients' Outcomes Undergoing Open Heart Surgeries" that the highest percentage of patients in the study group had a university degree, whereas the majority of patients in the control group had only a secondary education. The present findings, however, are at odds with those of **Downing et al., (2019)**, who found that 46% of 171 survivors of cardiothoracic surgery had less than a bachelor's degree.

As regards place of residency, the present study revealed that **the highest percentage of study group patients** resided in urban areas, **while the control group patients** resided in rural areas. **Abdallah et al., (2023)** noted in a study titled "Impact of comprehensive discharge program on patients' outcomes after open heart surgery" that over three-quarters of the patients were from metropolitan regions, which is consistent with the current results. Additionally, this result is in line with **Elesawy et al., (2019)**, who found that the largest proportion of the study group resided in an urban location. Additionally, **Kodaman et al., (2016)** noted that almost two-thirds of the study group's patients lived in urban areas, which is consistent with the current findings.

Concerning occupation, the current study showed that the highest percentages of patients in both the study and control groups were working, but their monthly income was insufficient. According to the researchers, this can be explained by the fact that their disease has a significant impact on their financial situation in addition to their family obligations, particularly because the highest percentages of them are married. The findings align with those of **Beltagy et al., (2022)**, who demonstrated in their study "Effect of inspiratory muscle training program on health outcomes among patients with thoracic surgery" that over half of the population under study was employed.

These findings also accord with those of **Ávila & Fenili (2017)**, who found that the largest proportion of patients were employers in their study on "Incidence and risk factors for postoperative pulmonary complications in patients undergoing thoracic and abdominal surgeries." While these results are not in line with those of **Downing et al., (2019)**, who discovered that the majority of the study participants were unemployed and retired.

Concerning smoking habits, the current study revealed that the highest percentage of patients in the study group do not smoke, whereas the majority of patients in the control group do. These findings coincide with those of **Al-Ebrahim et al., (2023)**, who found that the highest percentage of the patients under study did not smoke. The current findings, however, are in contrast with **Zeruxin Luo et al., (2023)**, who found that over two-thirds of the study group's patients smoked, while over half of the control group did not smoke.

Concerning life status and family support, the results of the current study demonstrated that the largest percentage of both the study and control groups lived with family and had family support. The current findings corroborate with **Bsharat (2024)**, who noted that none of the intervention and control group patients lived alone in the study "Effects of a patient education program on quality of life and post-discharge issues following coronary artery bypass grafting surgery."

Secondly, patients' knowledge regarding cardiothoracic postoperative exercises throughout the preoperative therapeutic exercises education program intervention phases:

Regarding the knowledge domains of the studied patients, the current study found no statistically significant differences between the study and control groups' knowledge domains during the pre-intervention phase of the preoperative therapeutic exercises education program in their knowledge domains about

cardiothoracic post-operative exercises and CTs complications that may arise if post-operative exercises are not performed. Although there was a highly statistically significant improvement and difference in knowledge domains between the two groups during the program's post-intervention phase, the study group patients' total mean score for knowledge domains was higher than that of the control group, and their improvement was more obvious at the post-intervention phase than it was at the pre-program.

The current findings are in alignment with those of **Ahmed et al., (2023)**, who found that the total mean score for thoracic surgery and pulmonary care before and immediately after implementation of an evidence-based nursing program showed substantial statistically significant variations. These findings are also consistent with those of **Amin et al., (2021)**, whose study focused on the "Effect of three pulmonary ventilation regimes in patients undergoing coronary artery bypass graft surgery" and discovered that, before the start of a training program, the most of the patients in the study possessed an inadequate level of total mean knowledge regarding thoracic surgery and inspiratory muscle training.

The results of a study by **Abass et al., (2020)** titled "The impact of pre- and postoperative education on recovery period following cardiothoracic surgery" also support these findings. They claimed that there were significant differences in the mean score of the patients' knowledge before and after education and that patients' knowledge of deep breathing exercises—one of the post-operative exercises for cardiothoracic surgery—improved significantly after receiving planned education. This demonstrated the value of preoperative education in increasing patients' awareness of the significance of this exercise.

Concerning the overall knowledge of studied patients regarding cardiothoracic post-operative exercises during the intervention phases of the preoperative therapeutic exercises education program, the current study found that during the pre-intervention phase of the program, the highest percentages of patients in both groups had an unsatisfactory level of overall knowledge. Conversely, at the post-intervention phase of the program, the majority of the patients in the study group achieved a satisfactory level of overall knowledge regarding CTs post-operative exercises, but only less than half of the patients in the control group did. Although both groups' overall knowledge scores improved post-program, the study group's overall satisfactory knowledge score improved more noticeably during the program's post-intervention phase than during the pre-program phase when compared to the control group.

According to the researchers' point of view, the lack of overall knowledge about cardiothoracic postoperative therapeutic exercises in the study or control groups during the pre-phase of the program may be linked to the decline in the role of healthcare providers (physicians and nurses) in educating patients about their health, which may be attributed to their increasing workload. This is supported by improvements or differences that occur in the study group as compared to the control group at the post-intervention phase of the program, which demonstrates the program's effectiveness on the study group subjects, especially **the** highest proportion of them holding a university degree.

The current findings are consistent with those of **Honnalli & Hadapad (2024)**, who demonstrated that prior to the program's implementation, over two-thirds of the subjects in both the experimental and control groups had a moderate level of overall knowledge about postoperative exercises. After the program intervention, all of the experimental group's individuals gained a sufficient level of knowledge. Meanwhile, **Said et al., (2022)** found that following the education guidelines intervention, postoperative knowledge regarding heart surgery had improved for cardiac patients. These findings are also consistent with those of **Azer et al., (2021)**, who discovered that study groups' overall scores for knowledge and anxiety about open heart surgery improved significantly over the course of educational program phases immediately following and after the program's implementation.

Furthermore, **Özdemir & Önler (2021)** showed in their study "The effect of a

structured patient education intervention on the quality of life for coronary artery bypass grafting patients: A prospective randomized controlled study" that there were significant differences between the overall knowledge scores before and after the intervention, with the post-intervention scores being higher than the pre-intervention scores. The study "Active gas aspiration to reduce pain after cardiothoracic" by **Surla et al., (2019)** also showed that patients' general knowledge improved following the education program, follow-up, and post-hospital discharge follow-up call.

Thirdly, patients' practice for cardiothoracic postoperative exercises throughout preoperative therapeutic exercises education program intervention phases:

Concerning the practice domains of the studied patients, the current study found that during the pre-intervention phase of the preoperative therapeutic exercises education program, there was no statistically significant difference between the study and control group patients' practice domains for cardiothoracic post-operative exercises. While there was a highly statistically significant improvement and difference between the two groups in all practice domains for cardiothoracic post-operative exercises, such as deep breathing, incentive spirometry, coughing, arm stretching, turning, leg walking, and stair climbing exercise, at the post-intervention phase of the program. The study group patients' total mean score for practice domains was higher than that of the control group, and their improvement was more pronounced at the post-intervention phase of the program than it was at the pre-program phase.

The present findings concur with those of **Elatar (2021)**, who reported that the majority of patients had an inadequate mean practice level for inspiratory muscle exercises before the start of a training program but that this level improved after the program was implemented. Additionally, the current results are consistent with those of **Raghavendran (2019)**, who found that patients' practice mean score and standard deviation for post-operative exercises increased gradually from the first to the fifth day following video-assisted patient instruction, as the practice mean score and standard deviation for post-operative exercises were 7.17 and 1.39 on the first day and raised to 35.58 and 2.25 on the fifth day.

Furthermore, the results of this study also align with those of **Awad et al., (2018)**, who explained that following the implementation of an exercise program, there was a statistically significant difference in post-operative exercise performance among subjects in the study group (p-value 0.001) compared to the control group in areas such as range of motion exercises, early ambulation, and chest physiotherapy exercises (breathing exercises, coughing exercises, and incentive spirometry). Also, **Akbari (2014)** made clear that planned preoperative education and training improve postoperative deep breathing and coughing abilities of patients and demonstrated that patients in the intervention group had fewer respiratory difficulties than those in the control group during the recovery period. They attributed this to their improved practice of deep breathing and coughing exercises as well as their use of a spirometer following training, which had a positive impact on their recovery.

Concerning the overall practice of studied patients for cardiothoracic post-operative exercises, the current study found that more than three-quarters of the study group and more than two-thirds of the control group patients had unsatisfactory practice levels for cardiothoracic post-operative exercises during the pre-intervention phase of the preoperative therapeutic exercises education program. Conversely, at the post-intervention phase of the program, the majority of the patients in the study group achieved a satisfactory level of overall practice for CTs post-operative exercises, whereas less than half of the patients in the control group did. Although both groups' overall practice scores improved post-program, the study group's overall satisfactory practice score improved more noticeably during the program's post-intervention phase than during the pre-program phase when compared to the control group.

According to the researchers' point of view, the reason why the study group patients' overall practice level for cardiothoracic postoperative exercises was unsatisfactory during the pre-

intervention phase of the preoperative therapeutic exercises education program were that most of the patients in the study group had inadequate knowledge at the time, which is thought to be the main barrier to improving their overall practices. As a result, the study group's increased knowledge during the post-intervention phase of the preoperative exercises education program was reflected in their practice for CTs postoperative therapeutic exercises.

The present results are consistent with those of **Honnalli & Hadapad (2024)**, who said in their study on the "Impact of video-based teaching programs on the knowledge and implementation of post-surgical exercises in patients with abdominal operations" that all of the experimental group's subjects had good-level post-operative exercise practices following the application of the teaching program, while 60% of the control group's subjects had poor practices and 40% had average practices. Additionally, the current findings are in line with **Ahmed et al., (2023)**, who found that all of the patients in the study had poor practices of pulmonary care techniques before the implementation of an evidence-based nursing program but that they all improved to a high level of competency after that.

Moreover, **Awad et al., (2018)** further demonstrated that following program implementation, the study group's patients had a high cardiac exercise self-efficacy score, ranging from 4.4 to 5.0. Likewise, the results of this study correspond with those of **Cheekavolu et al., (2017)**, who found that all patients (100%) lacked sufficient postoperative exercise knowledge and practice before the video-assisted instruction intervention but that this proportion improved following it. Furthermore, **Gad Allah (2012)** confirmed the current findings by showing that following program intervention, the study group exhibited higher levels of cardiac exercise self-efficacy than the control group.

Fourthly, patients' clinical outcomes through the post-intervention phase of the preoperative therapeutic exercises education program:

Concerning clinical outcomes of circulatory status in studied patients at the post-intervention phase of the preoperative therapeutic exercises education program, the current study found that during the post-intervention phase of the program, the clinical outcomes related to circulatory status showed highly statistically significant differences between the study and control groups. The highest percentage of patients in the study group had better or normal clinical outcomes for circulatory status compared to the control group; they hadn't experienced extreme fatigue, and their pulse pressure, systolic blood pressure, and peripheral tissue perfusion were in IER. Furthermore, there is a statistically significant difference between the study and control groups in other clinical outcome parameters related to the circulatory state. For example, the heart rate and diastolic blood pressure of the majority of study group patients were IER compared to the control group. Overall, there was a statistically significant improvement and differences between the study and control groups in all circulatory status clinical outcomes at the post-intervention phase of the program.

From the researchers' perspective, education plays a fundamental role and has the ability to alter patients' knowledge, practices, and behaviors in ways that improve their health outcomes following surgery. So, the improvement in the study group patients' outcomes more than the control group may have been caused by the hands-on training in therapeutic exercises that they received through the educational program, as the use of simple and appealing media, as well as ongoing demonstration and re-demonstration, may have a positive effect on knowledge and practice, which in turn may reflect on patients' outcomes.

These findings coincide with those of **Abdallah et al., (2023)**, who showed that the majority of patients had unsatisfactory total outcomes prior to program implementation but that most patients had satisfactory total outcomes following program implementation and follow-up. The authors attributed the prior results to the beneficial effects of educational guidelines on patient clinical outcomes and the power of education to increase knowledge and alter lifestyle behaviors that improve patient conditions and postoperative clinical outcomes.

Furthermore, **Maarouf & Ameen (2021)** support the current findings by showing in a study titled "Influence of Care Protocol on Nurses' Performance and Clinical Outcomes for Patients with Tube Thoracostomy" that there were improvements and statistically

significant differences between the study group and control group of thoracostomy patients regarding their circulatory status clinical outcomes. They also concluded that the application of care protocol for thoracostomy patients had a significant positive effect on the outcomes of patients in the study group as opposed to the control group.

Concerning clinical outcomes of respiratory status associated with gas exchange in studied patients at a post-intervention phase of the preoperative therapeutic exercises education program, the present study revealed that generally, all the gas exchange clinical outcomes parameters showed statistically significant improvement and differences between study and control group at the post-intervention phase of the program, as the highest percentage of patients in the study group had gas exchange normal clinical outcomes compared to control group, the majority of study group patients didn't have either dyspnea at rest or with exertion, didn't have cyanosis and somnolence, their arterial pH within normal range and O_2 saturation 95%; more than three-quarters of them their PaO_2 & $PaCo_2$ within normal range. Furthermore, the majority of study group patients—nearly three-quarters of them—had normal mental status, hadn't restlessness, had ease of breathing, and their chest X-ray findings were normal.

These results are in line with those of **Bsharat (2024)**, who showed that patients in the intervention group who were given a booklet and a DVD for preoperative education had fewer respiratory problems than patients in the control group who were given standard hospital instructions. Also, significant variations between the control and intervention groups were noted. Furthermore, these results agree with those of **Elgazzar et al., (2023)**, who discovered that patients' physiological parameters improved following the educational program. They found that arterial blood gases showed significant differences between before and after the program, with PaO2 improving from 88.02 ± 0.89 to 99.15 ± 0.68 and PaCO2 improving from 42.72 ± 0.78 to 37.18 ± 0.75, respectively ($p = 0.05$).

The present findings also concur with those of **Maarouf & Ameen (2021)**, who found that there were notable differences between the clinical outcomes of the study and control groups with regard to gas exchange following the application of the care protocol for the patient. Also, they demonstrated that aftercare protocol application, most of the study group patients did not exhibit cyanosis, had an oxygen saturation of 95%, did not exhibit dyspnea during exertion or at rest, and had normal arterial pH, PaO2, and PaCO2 levels.

Concerning clinical outcomes of respiratory status associated with ventilation in studied patients at the post-intervention phase of the preoperative therapeutic exercises education program, the present study demonstrates that totally, all the ventilation clinical outcomes showed statistically significant improvement and differences between the study and control groups in the post-intervention phase of the program, as the highest percentage of patients in the study group had ventilation better or normal clinical outcomes compared to a control group, and the majority of them hadn't chest retraction, PFT using a spirometer in the predicted or expected range, exhibited symmetrical chest expansion, no adventitious breath sounds, the auscultated breath sound was normal, and their percussion sounds were normal for almost three-quarters of them. Furthermore, the majority of study group patients exhibited IER of respiratory rates and rhythms, no orthopnea, acceptable vocalization, no use of accessory muscles, and hadn't shortness of breath.

These results concur with those of **Abdelkader (2024)**, who discovered that patients in the experimental group outperformed the control group in physiological parameters such as respiratory rate and rhythms, heart rate, blood pressure, and oxygen saturation. Additionally, the current findings are corroborative with those of Maarouf **& Ameen (2021)**, who found that overall respiratory status concerning ventilation outcomes showed statistically significant differences between the study and control groups, as most of the study group patients demonstrated improvements in respiratory rate and rhythm, symmetrical chest expansion, adequate vocalization, absence of adventitious breath sounds, normal percussion and auscultation of breath sounds, normal PFT

using a spirometer, and no signs of shortness of breath, chest retraction, or pursed lips breathing.

These results are further supported by **Awad et al., (2018)**, who observed a statistically significant difference in respiratory outcomes between the treatment and control groups. They linked this to the use of spirometers that increase lung capacities as well as preoperative coughing and breathing exercises. Furthermore, **Zeena et al., (2017)** found in their study "Meta-analysis of Thoracoscopy in Elderly Patients" that educating patients about postoperative exercise performance before surgery can help lower the risk of postsurgical complications after thoracic surgery, particularly pulmonary complications. This finding supports the findings of the current study.

Concerning clinical outcomes of wound status in studied patients at the post-intervention phase of the preoperative therapeutic exercises education program, the present study indicated that there is a highly statistically significant improvement and difference between study and control group patients in all items of wound status clinical outcomes at the post-intervention phase of the therapeutic exercises education program. The highest percentage of patients in the study group expressed negative wound culture and didn't have WBC elevation or foul-smelling discharge. In addition, there is statistically significant improvement and difference between study and control group patients in other wound status clinical outcomes, as the majority of study group patients as well as more than three-quarters of them, respectively, hadn't purulent drainage or pain/tenderness at the wound site.

The current study's results are parallel with those of **Gillespie et al., (2023)**, who calculated that with better education and more frequent follow-up, up to 50% of wound complications that result in readmissions can be avoided. Likewise, **Mahmoud et al., (2023)** found that the study group experienced significantly fewer postoperative complications than the control group, suggesting that raising patient awareness in the study group helped to prevent or lessen these complications. They also stressed the importance of educational programs for postoperative patients, as they can help them improve their health and thereby avoid many postoperative problems.

The current findings reinforce those of **Maarouf & Ameen (2021)**, who found statistically significant differences between the study and control groups in all aspects of wound and infection status following the implementation of the care protocol for patients with thoracostomy. These differences included the absence of WBC elevation, the absence of wound site culture, the absence of pain or tenderness at the wound site, and the absence of purulent drainage or foul-smelling discharge in all of the study group patients. Additionally, **Klaiber et al., (2018)** demonstrated how patient education could enhance patients' wellbeing and avoid postoperative problems. In addition, **Shah et al., (2016)** showed that early mobilization and exercise practice seem to be essential for minimizing the length of hospital stay, improving functional outcomes, and preventing postoperative complications in patients who have had heart surgery.

Concerning clinical outcomes of pain severity level in studied patients at the post-intervention phase of the preoperative therapeutic exercises education program, the current study showed that generally there was highly statistically significant improvement and difference between study and control group patients at the post-intervention phase of the program regarding pain severity level, as the study group's lowest percentage of patients experienced severe pain, with 13.3% reporting no pain, while the control group's highest percentage of patients experienced severe pain, with none of them reporting no pain.

These findings are consistent with those of **Bsharat (2024)**, who discovered that the intervention group showed a consistent reduction in pain levels, while the control group reported more severe pain upon discharge and during the three follow-up evaluations. Furthermore, these findings are corroborated by **Gsangaya et al., (2023)**, who revealed that following program intervention, the study group and control group differed significantly in terms of improvement in pain levels ($p = 0.012$) and function scores ($p =$

0.024). Meanwhile, **Wudu (2020)** reported that many of the patients in the study reported less pain four hours after surgery, which progressively lessens over the first twenty-four hours. They also reported being able to shift positions more easily after successfully completing coughing and deep breathing exercises after surgery. The present findings are also consistent with **Weeks et al., (2018)**, who discovered statistically significant differences between groups in the global rating scale score for pain severity two weeks after cardiothoracic surgery.

On the other hand, the present results are in contrast to **Brunet et al., (2017)**, who reported that there was no evidence of a statistically significant difference between the intervention group and the control group and that there was variation in pain, fatigue, mental health perceptions, insomnia, and physical health perceptions with respect to QoL, with p = 0.67, 0.10, 0.90, 0.89, and 0.34, respectively, observed before and after programs.

Fifthly, the correlation between the study variables:

Concerning the correlation between study group patients' overall clinical outcomes score, knowledge, and practice at a post-intervention phase of the preoperative therapeutic exercises education program, the current study results found that there was a highly statistically significant positive correlation of the study group patients' clinical outcomes with their overall knowledge and practice score at the post-intervention phase of therapeutic exercises education program and vice versa. This implies that improving patients' knowledge about CTs' postoperative therapeutic exercises and their commitment to practicing them will improve or have an impact on their clinical outcomes. Also, there was a highly statistically significant positive correlation between study group patients' knowledge and practice and vice versa.

These findings are in line with those of **Abdallah et al., (2023)**, who discovered a statistically significant positive association between patients' overall outcomes and their total knowledge at the post- and follow-up program implementation phases. Furthermore, health education has been shown to improve quality of life and patient outcomes by **Elgazzar et al., (2023)**, as evidenced by the significant differences in all elements of QoL and outcomes between before and after the implementation of educational programs.

Additionally, the current findings are in agreement with those of **Al-Ahdal & Ahmed (2020)**, who carried out a quasi-experimental design at Sudan Heart Center for a total of 128 patients and demonstrated that knowledge improvement and education programs improve patient outcomes, as evidenced by the absence of postoperative complications and patient satisfaction. Moreover, **Alkan et al., (2018)** noted that the outcomes following open heart surgery can be impacted by nursing education and the adoption of healthy lifestyle practices. Likewise, **Ünver et al., (2018)** confirmed that education had a good impact on patients' exercise performance status and discovered a high positive correlation between knowledge and practice of breathing exercises.

Concerning the best-fitting multiple linear regression model for the clinical outcomes score among study group patients, the current study indicated that the main statistically significant positive predictor of the study group patients' clinical outcomes is their practice of cardiothoracic postoperative therapeutic exercises since the highest clinical outcomes are linked to high levels of practice. However, none of the other patients' variables had a significant effect on the clinical outcomes score. The model demonstrates 71% of the variation in the clinical outcomes scores following program implementation, based on the r-square value.

These findings are confirmed by **Legnani et al., (2023),** who reported that patients with higher practice values showed superior functional and clinical outcomes. Also, **Emmanuel (2021)** demonstrated that not exercising or engaging in any physical activity was associated with unfavorable outcomes, while practicing exercises for six to nine months was predictive of positive functional outcomes. Moreover, **Gad Allah (2012)** documented that participation in early rehabilitation is the positive predictor of patients' overall physical outcomes that were not affected by age, gender, or co-morbidities.

Conclusion:

Since there was a statistically significant improvement and difference in knowledge, practice, and clinical outcomes between study and control group patients at the post-intervention phase of the program, it can be concluded that the preoperative therapeutic exercises education program, which is based on previously assessed needs of patients undergoing CTs, is taking into consideration an effective nursing strategy in enhancing patients' clinical outcomes. Compared to the control group, the study group patients' knowledge and practice regarding cardiothoracic postoperative exercises improved during the program's post-intervention phase as a result of the preoperative therapeutic exercises education program. This improvement was reflected in their clinical outcomes, which included their circulatory, respiratory, wound, and pain severity conditions. This was confirmed by either the multiple linear regression model, which showed that practice of CTs postoperative exercises is the main statistically significant positive predictor of clinical outcomes for the study group patients since their highest clinical outcomes are associated with high practice level for these exercises, or the correlation analysis, which showed a highly statistically significant positive correlation of improved clinical outcomes for study group patients with their knowledge and practice at the post-intervention phase of the program. These findings support the hypotheses of the current study and confirm a significant positive effect of the program.

Recommendation:

In view of the study results, the study recommends the following:

- Preoperative teaching sessions regarding postoperative therapeutic exercises should be given to patients scheduled for CTs. This will assist the patients in completing these exercises effectively, correctly, and independently, which will improve their health outcomes.
- Provision of colorful posters, handouts, and educational booklets regarding postoperative therapeutic exercises at the cardiothoracic department and outpatient clinic for patients.
- To increase the postoperative therapeutic exercises application rate among patients undergoing CTs, clinical nurses should receive in-service education on the significance of incorporating postoperative therapeutic exercises as a fundamental component of standard nursing care.
- There should be widespread implementation of the preoperative therapeutic exercises education program in study settings and all comparable ones, including all government hospitals.

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