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Effects of PechaKucha-Based Education on Nursing Students' Knowledge of Cardiovascular Surgery ERAS and Attitudes Toward Evidence-Based Nursing: A Randomized Controlled Trial

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Abstract

Background

Enhanced Recovery After Surgery (ERAS) protocols are evidence-based, multimodal perioperative pathways requiring adequate nursing knowledge and positive attitudes toward evidence-based practice. Cardiovascular surgery (CVS)-ERAS is often taught using conventional presentations. PechaKucha (PK), a concise, visually focused format, may offer an alternative approach to support learning. To compare PK-based with conventional PowerPoint-based education on nursing students' knowledge of CVS-ERAS protocols and attitudes toward evidence-based nursing, including one-month follow-up outcomes.

Methods

This parallel-group randomized controlled trial included 70 nursing students in Türkiye, allocated 1:1 to PK-based (n = 35) or PowerPoint-based education (n = 35). Randomization was stratified by sex using block randomization. Outcomes were assessed at pre-test, post-test, and one-month follow-up using the CVS-ERAS Protocol Knowledge Test and Evidence-Based Nursing Attitude Scale. Data were analyzed using mixed-design ANOVA, Friedman tests, and multiple linear regression with multiple imputation for intention-to-treat analyses. The Benjamini-Hochberg procedure controlled the false discovery rate.

Results

Sixty-four students completed the study (PK: n = 30; PowerPoint: n = 34). ERAS knowledge scores changed significantly over time ($F = 33.806$, $p < .001$, $\eta p^2 = .351$), but neither the group effect ($F = 0.824$, $p = .368$, $\eta p^2 = .013$) nor the group × time interaction ($F = 1.518$, $p = .223$, $\eta p^2 = .024$) was significant. Total Evidence-Based Nursing Attitude Scale scores showed no significant changes over time or between groups. The Beliefs and Expectations subscale improved within the PK group ($\chi^2 = 15.128$, $p = .001$), but no between-group differences were observed. After false discovery rate correction, the control group's Feelings subscale change was no longer significant. Intention-to-treat analyses yielded similar findings.

Conclusion

PK-based education was not superior to conventional PowerPoint-based education in improving ERAS knowledge or overall attitudes toward evidence-based nursing. PK may be better positioned as a complementary component of multimodal educational approaches rather than a standalone method.

Trial registration

ClinicalTrials.gov, NCT07606144 registered on April 9, 2026.

Background

Cardiovascular surgery is a complex clinical field that requires advanced perioperative care due to an aging patient population and increasing comorbidities [1]. In addition to advances in surgical techniques, improving the quality of perioperative care is critical for enhancing patient outcomes. Enhanced Recovery After Surgery (ERAS) protocols have been developed to address this need; these are evidence-based, multimodal care pathways spanning the preoperative, intraoperative, and postoperative periods that aim to reduce physiological stress, minimize complications and morbidity, and accelerate recovery [2, 3].

Successful implementation of ERAS protocols requires not only multidisciplinary teamwork but also nurses' adequate knowledge and skills regarding these pathways [4]. Many ERAS components, including patient education, early mobilization, pain management, maintenance of nutrition, and monitoring for complications, fall directly within the scope of nursing care [5–7]. Accordingly, it is important for nursing students to learn ERAS principles and their underlying scientific evidence during their undergraduate education so that they can provide evidence-based perioperative care after graduation. Furthermore, as nursing evolves as a science-based discipline, students must not only acquire knowledge but also embrace the role of scientific evidence in clinical practice and develop positive attitudes toward evidence-based nursing [8].

ERAS encompasses numerous components across the preoperative, intraoperative, and postoperative phases and relies on continuously updated evidence, making it a comprehensive and cognitively demanding learning domain for nursing students [9–11]. In nursing education, such complex theoretical content is often delivered through traditional lectures and text-heavy Power Point presentations. This approach may hinder students' ability to sustain attention, distinguish key information, and make sense of relationships among concepts, particularly in information-dense topics. Therefore, there is a need to present complex nursing content using more structured, focused, and attention-supportive instructional methods [12].

In this context, Pecha Kucha (PK) emerges as an innovative teaching approach that integrates visual and verbal learning within a time-limited presentation format. Developed by Astrid Klein and Mark Dytham, PK consists of 20 slides, each displayed for 20 seconds, resulting in a total duration of 6 minutes and 40 seconds [13]. This structure requires the presenter to select and organize content carefully while supporting learners' simultaneous processing of visual and verbal information. It has been suggested that the time-limited and visually focused nature of PK may reduce extraneous cognitive load, facilitate clearer structuring of key messages, and help sustain students' attention [14, 15].

The PK method has been used in nursing education across various content areas, including pathophysiology, stoma care, intramuscular injection techniques, vital signs assessment, and presentation skills, with reports of improved student engagement, satisfaction, and learning experience [14, 16–19]. However, findings regarding the effects of PK on learning outcomes are not consistent across all studies. For example, Akdağ Topal et al. [20] reported that PK did not provide a significant

advantage over traditional presentations in terms of knowledge levels and suggested that the effectiveness of the method may depend on the educational content and context. These mixed results indicate that the effectiveness of PK should be further evaluated in different, particularly complex, educational contents.

ERAS education in cardiovascular surgery, with its multi-component structure and emphasis on evidence-based care principles, offers an appropriate context for investigating the potential benefits of the PK method among nursing students. To the best of our knowledge, existing studies have focused on the use of PK in various nursing topics, and no study has specifically examined the effect of PK-based education on nursing students' knowledge of cardiovascular surgery ERAS protocols. Moreover, the impact of PK-based education on students' attitudes toward evidence-based nursing remains underexplored. Therefore, it is important to evaluate not only the effect of PK on knowledge acquisition but also its potential influence on students' understanding of and attitudes toward evidence-based nursing [10].

Accordingly, this randomized controlled trial compared the effects of PK-based cardiovascular surgery ERAS education with conventional PowerPoint-based ERAS education on nursing students' knowledge of ERAS protocols and attitudes toward evidence-based nursing. In addition, the retention of ERAS-related knowledge and the sustainability of attitudes toward evidence-based nursing approximately one month after the educational intervention were evaluated.

Aim

This randomized controlled trial aimed to compare PK-based and conventional PowerPoint-based education in terms of nursing students' knowledge of cardiovascular surgery ERAS protocols and attitudes toward evidence-based nursing. It also examined whether these outcomes were retained or maintained approximately one month after the educational intervention.

Hypotheses

H1. Nursing students receiving PK-based education will demonstrate a greater change in knowledge of cardiovascular surgery ERAS protocols over time than those receiving conventional PowerPoint-based education.

H2. Nursing students receiving PK-based education will demonstrate a greater change in attitudes toward evidence-based nursing over time than those receiving conventional PowerPoint-based education.

Methods

Study design

This study was conducted as a parallel-group randomized controlled trial with a 1:1 allocation ratio and pre-test, post-test, and follow-up assessments. The study aimed to compare the effectiveness of PK-based education with conventional PowerPoint-based education on nursing students' knowledge of ERAS protocols in cardiovascular surgery and their attitudes toward evidence-based nursing. The trial was prospectively registered with ClinicalTrials.gov (NCT07606144) and was reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) 2025 guidelines [21] (Fig. 1).

Participants and setting

This study was conducted at the Faculty of Nursing, Lokman Hekim University, Ankara, Türkiye, between 15 April and 15 June 2026. The target population comprised second-year undergraduate nursing students enrolled in the Surgical Nursing course.

Inclusion Criteria:

- were enrolled as second-year undergraduate nursing students,
- were actively enrolled in the Surgical Nursing course,
- had no prior formal training in ERAS protocols for cardiovascular surgery,
- had access to the internet and a computer or smartphone,
- provided written informed consent.

Exclusion Criteria

Students who did not meet the inclusion criteria were excluded from the study.

Sample Size Calculation

The accessible population comprised 71 students enrolled in the Surgical Nursing course during the study period, and a convenience sampling approach was used. No a priori power analysis was performed to determine the sample size. All students who were accessible during the study period and met the eligibility criteria were invited to participate. Of the 71 students assessed for eligibility, one was excluded because they did not meet the inclusion criteria, resulting in 70 eligible participants who were enrolled in the study. The 70 participants were randomly allocated to the experimental group (n = 35) or the control group (n = 35). Six participants were subsequently lost to post-test or follow-up assessments, resulting in a final sample of 64 participants (experimental group, n = 30; control group, n = 34). The overall attrition rate was 8.6%. Participant recruitment, eligibility assessment, randomization, follow-up, and analysis are presented in the CONSORT flow diagram (Fig. 1).

To assess potential attrition bias, baseline knowledge scores were compared between participants who completed the study and those who withdrew. An independent-samples t-test showed no statistically

significant difference in baseline scores between the groups (t = 0.988, p = 0.354). The multiple imputation model (m = 6) included baseline demographic characteristics, group allocation, and all measurement time points (pre-test, post-test, and re-test). The consistency between the complete-case and imputed analyses supported the robustness of the findings.

Randomization and Blinding

Sequence Generation

Following completion of the pre-test, participants were randomly allocated in a 1:1 ratio to either the PK intervention group or the conventional PowerPoint control group. Randomization was performed by an independent researcher who was not involved in participant recruitment, intervention delivery, or outcome assessment, using the web-based Randomizer.org service. Participants were stratified by sex, and block randomization with a block size of four was performed within each stratum. Participants were identified in the randomization system using their student identification numbers. The researchers did not alter or influence the resulting group assignments.

Allocation Concealment

To ensure allocation concealment, the randomization sequence was generated by an independent researcher who was not involved in participant recruitment, intervention delivery, or outcome assessment. Randomization was performed only after completion of the pre-test. The researchers responsible for participant recruitment and pre-test administration did not have access to the allocation sequence before randomization. Following randomization, group assignments were communicated to participants through the class representative.

Blinding

Participants were informed before the pre-test that cardiovascular surgery ERAS education would be delivered using two different presentation methods but were not informed of their specific group assignment or the presentation method they would receive before the intervention. Because of the visible differences between the PK and conventional PowerPoint formats, participants and instructors could not be blinded during the intervention. The instructors were aware of group assignments because they delivered the respective educational sessions.

Outcome data were collected using Google Forms and linked across the pre-test, post-test, and follow-up assessments using participants' student identification numbers. After data collection, the dataset was reviewed and prepared by an independent research assistant. Identifying information was removed before the dataset was provided to the statistician, and intervention groups were coded as “Group A” and “Group B.” The statistician responsible for the outcome analysis was blinded to the intervention labels and analyzed the dataset using only the coded group identifiers. Group identities were disclosed only after completion of the primary analyses.

Instruments

Data were collected using the Student Descriptive Information Form, the Cardiovascular Surgery ERAS Protocol Knowledge Test, and the Evidence-Based Nursing Attitude Scale (EBNAS).

Student Descriptive Information Form

The form included four items assessing students' age, sex, prior knowledge of ERAS practices.

Cardiovascular Surgery ERAS Protocol Knowledge Test

The test was developed by the researchers based on the relevant literature [1, 4, 11] to assess nursing students' theoretical knowledge of ERAS protocols in cardiovascular surgery. The test comprised 25 questions covering preoperative, intraoperative, and postoperative ERAS practices. The questions included multiple-choice and true–false formats, including table-format true–false questions. Each question was equally weighted, and the total score was standardized to 0–100, with higher scores, indicating greater knowledge of cardiovascular surgery ERAS protocols (see Supplementary File 1 for the English language version).

Content validity was evaluated by seven experts, including five faculty members specializing in surgical nursing and two clinical nurses with expertise in cardiovascular surgery. The Content Validity Index (CVI) of the knowledge test was 0.90. The items were revised in accordance with the experts' feedback, and the final version of the test was established [22]. The internal consistency reliability of the knowledge test was assessed using the Kuder–Richardson 20 (KR-20) coefficient for the 25-item dichotomously scored test. The KR-20 coefficients were 0.804 for the pre-test, 0.614 for the post-test, and 0.813 for the re-test. The pre-test and re-test values indicated good internal consistency, whereas a lower coefficient was observed for the post-test [23].

Evidence-Based Nursing Attitude Scale (EBNAS): The Scale was developed by Ruzafa-Martínez et al. [24] and adapted into Turkish by Ayhan et al. [25]. The scale consists of 15 items rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). It comprises three subdimensions: Beliefs and Expectations (7 items; score range, 7–35), Intention to Practice (4 items; score range, 4–20), and Feelings (4 items; score range, 4–20). The total score ranges from 15 to 75, with higher scores indicating a more positive attitude toward evidence-based nursing. Eight items are positively worded and seven are negatively worded; negative items are reverse-coded.

The Turkish version demonstrated good internal consistency, with a Cronbach's alpha coefficient of 0.90 for the total scale and 0.86, 0.69, and 0.71 for the three subdimensions, respectively [25]. In the present study, Cronbach's alpha coefficients for the total scale were 0.879 at pre-test, 0.854 at post-test, and 0.873 at follow-up.

Data Collection

All questionnaires were administered electronically at three time points: before the intervention (pre-test), immediately after the intervention (post-test), and one month after the intervention (follow-up). At the beginning or end of each relevant session, a QR code was displayed on the classroom screen, allowing students to access the questionnaires through Google Forms using their personal mobile devices. Participants' student identification numbers were collected solely to link their responses across the three assessment time points. The procedures for data anonymization, group coding, and blinding of the statistician are detailed in the Blinding section.

Preparation of Educational Materials

The educational material addressed ERAS practices applied during the preoperative, intraoperative, and postoperative periods of cardiovascular surgery. The content was prepared by the principal investigator with reference to the relevant literature [1, 11] and was subsequently reviewed by five faculty members with expertise in surgical nursing. Their feedback was incorporated into the final educational content.

The PK presentation was developed by a third-year nursing student who was the second author, under the supervision of the principal investigator. The principal investigator first specified the learning objectives and prepared the content framework together with the relevant source materials. The student transformed this content into a visual presentation using Canva Pro, with limited text and visual elements consistent with the PK format (Fig. 2). AI-assisted tools were used to create some of the visual elements. The principal investigator reviewed the completed presentation to ensure that the information presented was accurate, complete, and consistent with the predetermined educational content.

For the control group, the principal investigator prepared a conventional PowerPoint presentation using text, tables, and bullet points. The two presentations contained the same educational content and learning objectives; only the presentation format differed between groups.

Intervention and Procedure

The educational intervention was integrated into the regular 14-week Surgical Nursing course. During the first week, all students received a two-hour introductory session on ERAS, including its development, principles, and general perioperative components. During the second week, cardiovascular surgery nursing care was covered as part of the regular curriculum. At the end of the second week, before the cardiovascular surgery-specific ERAS intervention, participants completed the pre-test electronically using Google Forms. The pre-test included the Cardiovascular Surgery ERAS Protocol Knowledge Test and the Evidence-Based Nursing Attitude Scale. Participants were then randomly assigned to the intervention or control group according to the predetermined randomization procedure.

The cardiovascular surgery-specific ERAS intervention was delivered during the four-hour Wednesday session in the third week. Participants were informed of their group assignments through the class representative and directed to separate classrooms. The control group first received the ERAS content using a conventional PowerPoint presentation, while the intervention group remained in a separate

classroom under the supervision of the second researcher and engaged in routine individual academic activities without exposure to ERAS-related content.

Both sessions were delivered by the principal investigator, who had eight years of experience in perioperative nursing education and prior training in PK presentation techniques. Each session lasted a total of 60 minutes and included an educational presentation followed by a discussion period. Both groups received the same predefined educational content and learning objectives, covering the preoperative, intraoperative, and postoperative phases of cardiac surgery nursing. The conventional PowerPoint presentation used standardized text, tables, and bullet points, whereas the pre-recorded PK presentation followed the 20-second-per-slide format. Both groups had the opportunity to discuss the educational content. Thus, the presentation format was the primary difference between the two educational interventions, while the total session duration, educational content, learning objectives, and inclusion of discussion were consistent across groups.

Immediately after each session, participants completed the post-test electronically using Google Forms. The control group completed the post-test before leaving the teaching area, after which the intervention group received the same educational content using the PK format and completed the post-test. To minimize contamination, the sessions were conducted consecutively in separate classrooms. The intervention group remained under supervision while the control group completed the session and assessment, and participants were reminded not to exchange information about the intervention or assessment.

One month after the intervention, during approximately the seventh week of the course and before the midterm examinations, participants completed the follow-up assessment using the same outcome measures. After follow-up assessment, both groups received the alternative presentation format to ensure equitable access to the educational content. This subsequent exposure occurred after the follow-up assessment and was not included in the randomized comparison or outcome analyses.

Intervention fidelity was assessed by an independent observer who monitored adherence to the predefined content and presentation procedures. Attendance and participation were recorded, although formal compliance tracking was not performed.

A reflective account of the student co-researcher's experience during the development and delivery of the PK presentation is provided as supplementary material (see Supplementary File 2).

Outcomes

Primary outcome

Knowledge of cardiovascular surgery ERAS protocols, assessed using the Cardiovascular Surgery ERAS Protocol Knowledge Test. The primary outcome was measured at pre-test, immediately after the intervention (post-test), and one month after the intervention (follow-up).

Secondary outcome

Attitudes toward evidence-based nursing, assessed using the total score of the EBNAS. The secondary outcome was measured at pre-test, immediately after the intervention (post-test), and one month after the intervention (follow-up).

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA), by an independent statistician. Normality was assessed using the Shapiro–Wilk test. Age was not normally distributed; therefore, the Mann–Whitney U test was used for between-group comparisons. Categorical variables were presented as frequencies and percentages and compared using Fisher's exact test.

Changes in ERAS Knowledge Test scores across pre-test, post-test, and follow-up, as well as time, group, and time × group effects, were analyzed using mixed-design analysis of variance (mixed ANOVA). For the EBNAS and its subscales, within-group changes were assessed using the Friedman test, followed by Bonferroni-adjusted Wilcoxon signed-rank tests when significant. Between-group comparisons at each time point were performed using the Mann–Whitney U test. For repeated-measures analyses, sphericity was assessed using Mauchly's test; when violated, Greenhouse–Geisser corrections were applied. Partial eta-squared (ηp^2) effect sizes based on Type III sums of squares, with 95% confidence intervals (CIs), were reported to quantify the magnitude and precision of effects.

To control the increased risk of Type I error associated with multiple pairwise and subgroup comparisons, the false discovery rate (FDR) was controlled using the Benjamini–Hochberg procedure. Multiple linear regression analyses were conducted to compare post-test and follow-up ERAS Knowledge Test and EBNAS scores between groups, adjusting for the corresponding pre-test scores. Due to attrition (8.6%; intervention group, n = 5; control group, n = 1), analyses followed the intention-to-treat principle, with missing data handled using multiple imputation with the fully conditional specification algorithm (m = 6). Parameter estimates were pooled according to Rubin's rules. Statistical significance was set at $p < 0.05$.

Results

A total of 70 nursing students were randomly allocated to the intervention (n = 35) and control (n = 35) groups. Six participants (8.6%) were lost to follow-up at the post-test and/or follow-up assessments (intervention group, n = 5; control group, n = 1). The results are presented under four headings: participant characteristics, ERAS Knowledge Test scores, attitudes toward evidence-based nursing, and intention-to-treat (ITT) regression analyses.

Participant Characteristics

Most participants were female (85.7%), and the mean age was 21.03 ± 2.42 years. Baseline demographic characteristics were descriptively similar between the intervention and control groups (Table 1). Fisher's exact test for sex (p = 1.000) and the Mann–Whitney U test for age (U = 559.00, p = .389) were also performed as supplementary comparisons.

Table 1
A comparison of the characteristics of nursing students between the intervention and control groups (n = 70)

Variables	Intervention Group (*n*:35)		Control Group (*n*:35)		Total (*n*:70)		Statistical analysis
	N	%	*N*	%	*N*	%	
Gender							*p* : 1.000*
Female	30	85.7	30	85.7	60	85.7	
Male	5	14.3	5	14.3	10	14.29	
Age (Years)							*U* = 559.00**
Mean ± SD	21.13 ± 2.205		20.91 ± 2.649		21.03 ± 2.419		*p*: 0.389
Median	20		20		20		
ERAS Knowledge Test Score (Pre-test)							*t* = − 0.087, *p* = 0.931
Mean ± SD	28.72 ± 5.29		28.83 ± 5.00		28.77 ± 5.11		
Median	28		28		28		
EBNAS Total Score (Pre-test)							*t* = -1.179, *p* = 0.243
Mean ± SD	61.06 ± 11.05		63.83 ± 8.66		62.42 ± 9.97		
** Fisher's Exact Test was use.*							
***As the age variable did not follow a normal distribution, the Mann-Whitney U test was used.*							
Abbreviations: SD, standard deviation; Mean, mean. p < 0.05 was considered statistically significant.							

For the study outcomes, the mean pre-test knowledge scores were 28.72 ± 5.29 in the intervention group and 28.83 ± 5.00 in the control group, while the mean pre-test total EBNAS scores were 61.06 ± 11.05 and 63.83 ± 8.66, respectively (Table 1). These descriptive baseline values indicate broadly comparable distributions of the primary and secondary outcome measures between groups. Between-group tests yielded no statistically significant differences for the knowledge test (t = 0.087, p = .931) or EBNAS (t = − 1.179, p = .243). Given the randomized design, these baseline comparisons were considered descriptive rather than evidence that the groups were statistically equivalent.

ERAS Knowledge Test Results

Mean ERAS Knowledge Test scores at pre-test, post-test, and follow-up are presented in Table 2. At baseline, mean knowledge scores were similar in the intervention and control groups (28.60 ± 5.54 and 28.56 ± 4.81, respectively). A mixed-design ANOVA was conducted to examine the effects of time and group on knowledge scores. Mauchly's test indicated a violation of the sphericity assumption ($W = 0.899$, $p = .039$); therefore, Greenhouse–Geisser-corrected degrees of freedom and p values were used ($\varepsilon = 0.908$). There was a statistically significant main effect of time, $F(1.82, 112.62) = 33.806$, $p < .001$, $\eta p^2 = .351$, indicating that knowledge scores changed significantly across the three assessment points. In contrast, neither the main effect of group, $F(1, 62) = 0.824$, $p = .368$, $\eta p^2 = .013$, nor the time × group interaction, $F(1.82, 112.62) = 1.518$, $p = .225$, $\eta p^2 = .024$, was statistically significant. Thus, although knowledge scores changed over time, the pattern of change did not differ significantly between students receiving PechaKucha-based education and those receiving conventional PowerPoint-based education.

Table 2
Comparison of ERAS Knowledge Test Scores in the Intervention and Control Groups Over Time

Measurement Time	**Intervention Group (n:30)**		**Control Group (n:34)**		**Total (n:64)**		**Statistical Analysis**
	Mean ± SD	**Min-Max**	**Mean ± SD**	**Min-Max**	**Mean ± SD**	**Min-Max**	
Pre-Test	28.60 ± 5.537	16–39	28.56 ± 4.806	20–39	28.58 ± 5,120	16–39	*Time*: $F_{(1,82;\ 112,62)}$ = 33,806 p < 0,001 *(GG)*
Post-Test	32.53 ± 3.491	25–38	31.88 ± 3,355	24–38	32.19 ± 3,408	24–38	*Group:* $F_{(1.62)}$ = 0.824 p = 0.368
Follow-up	32.93 ± 3.939	25–39	31.17 ± 4.108	22–39	32.00 ± 4.094	22–39	*Time*Group effect*: $F_{(1,82;\ 112,62)}$ = 1,518 p = 0,225 *(GG)*

Note: Values are presented as Mean ± Standard Deviation (SD) and Minimum-Maximum. F and p values for the time factor and time-by-group interaction are adjusted using Greenhouse-Geisser correction (ε = 0,908) due to the violation of sphericity (Mauchly's test p = 0,039).

At the descriptive level, the overall mean knowledge score increased from 28.58 ± 5.12 at pre-test to 32.19 ± 3.41 at post-test and remained similar at follow-up (32.00 ± 4.09). In the intervention group, mean scores increased from 28.60 ± 5.54 at pre-test to 32.53 ± 3.49 at post-test and 32.93 ± 3.94 at

follow-up. In the control group, the corresponding means were 28.56 ± 4.81, 31.88 ± 3.36, and 31.17 ± 4.11, respectively. Bonferroni-adjusted pairwise comparisons showed that knowledge scores were significantly higher at post-test than at pre-test ($p < .001$) and remained significantly higher at follow-up than at pre-test ($p < .001$). No significant difference was observed between post-test and follow-up scores ($p = 1.000$), indicating that scores remained stable between these two assessment points. However, given the non-significant time × group interaction, the observed improvement over time cannot be attributed specifically to the PK format.

Attitudes Toward Evidence-Based Nursing Scores

Table 3 presents the total and subscale scores of the EBNAS at pre-test, post-test, and follow-up, together with the results of the within- and between-group comparisons. At baseline, the median total EBNAS score was 63.00 (IQR = 17.75) in the intervention group and 64.50 (IQR = 13.25) in the control group. No statistically significant difference was found between the groups at pre-test (U = 555.500, p = .391). Given the possible total score range of 15–75, these scores indicate that students in both groups had relatively positive attitudes toward evidence-based nursing at baseline.

Table 3
Comparison of the Evidence-Based Nursing Attitude Scale Scores and Subscale Scores of the Intervention and Control Groups Over Time

Scale / Sub-dimensions and Measurement Times	Intervention Group (n = 30)	Control Group (n = 34)	Inter-group Analysis	Intra-group Change Analysis	
	IQR	IQR	U^a, Z^a, p^a, r	Intervention Group (n = 30)	Control Group (n = 34)
χ², df, p^b					
Total Score on the Attitude Scale towards Evidence-Based Nursing (EBNAS)				$\chi^2 = 1.411$, $df = 2$, $p^b = 0.494$	$\chi^2 = 1.136$, $df = 2$, $p^b = 0.567$
Pre-Test	63.00 (17.75)	64.50 (13.25)	$U^a = 555.50$, $Z^a = -0.858$, $p^a = 0.391$, $r = 0.10$		
Post-Test	67.00 (9.25)	68.00 (15.00)	$U^a = 513.00$, $Z^a = -0.399$, $p^a = 0.690$, $r = 0.05$		
Follow- up	67.50 (11.75)	63.50 (20.25)	$U^a = 542.00$, $Z^a = -0.436$, $p^a = 0.663$, $r = 0.05$		
Beliefs and Expectations Regarding Evidence-Based Nursing				$\chi^2 = 15.128$, $df = 2$, $p^b = 0.001$** *(Ön-Son fark: $p^b{}_{adj} < 0.001$)*	$\chi^2 = 0.639$, $df = 2$, $p^b = 0.726$
Pre-Test	30.00 (6.25)	30.50 (7.25)	$U^a = 569.50$, $Z^a = -0.702$, $p^a = 0.482$, $r = 0.08$		
Post-Test	34.00 (6.00)	32.00 (7.00)	$U^a = 490.00$, $Z^a = -0.719$, $p^a = 0.472$, $r = 0.09$		
Follow- up	33.00 (7.00)	31.50 (7.00)	$U^a = 569.50$, $Z^a = -0.101$,		

			$p^a = 0.920$, $r = 0.01$		
Intention to Implement Evidence-Based Practice				$\chi^2 = 0.400$, $df = 2$, $p^b = 0.819$	$\chi^2 = 2.117$, $df = 2$, $p^b = 0.347$
Pre-Test	17.00 (4.25)	16.00 (4.25)	$U^a = 595.00$, $Z^a = -0.405$, $p^a = 0.686$, $r = 0.05$		
Post-Test	16.00 (3.25)	17.00 (4.25)	$U^a = 510.00$, $Z^a = -0.440$, $p^a = 0.660$, $r = 0.05$		
Follow- up	16.00 (3.25)	15.50 (7.50)	$U^a = 529.00$, $Z^a = -0.599$, $p^a = 0.549$, $r = 0.07$		
Feelings about Evidence-Based Nursing				$\chi^2 = 2.214$, $df = 2$, $p^b = 0.331$	$\chi^2 = 6.676$, $df = 2$, $p^b = 0.036$**
Pre-Test	18.00 (4.25)	19.00 (4.00)	$U^a = 526.50$, $Z^a = -1.225$, $p^a = 0.221$, $r = 0.15$		
Post-Test	18.50 (4.00)	19.00 (4.00)	$U^a = 535.50$, $Z^a = -0.115$, $p^a = 0.909$, $r = 0.01$		
Follow- up	19.00 (5.25)	17.50 (6.25)	$U^a = 545.50$, $Z^a = -0.408$, $p^a = 0.683$, $r = 0.05$		

Note. Data are presented as median (IQR) because the normality assumption was not met.
**a Mann–Whitney U test for between-group comparisons; U, Mann–Whitney U statistic; Z, Z statistic; r, effect size.*
**b Friedman test for within-group repeated-measures comparisons; χ², Friedman chi-square statistic; df, degrees of freedom.*
Post-hoc analysis. Wilcoxon signed-rank tests with Bonferroni correction were used to identify significant pairwise differences following the Friedman test.
Effect size. For non-parametric tests, effect size was calculated as r = Z/√N.
Abbreviations: IQR, interquartile range; df, degrees of freedom; U, Mann–Whitney U statistic; Z, Z statistic; χ², Friedman chi-square statistic; r, effect size; p_adj, adjusted p-value.

For the total EBNAS score, the median score in the intervention group increased from 63.00 at pre-test to 67.00 at post-test and 67.50 at follow-up. In the control group, the median score increased from 64.50 at pre-test to 68.00 at post-test and decreased to 63.50 at follow-up. However, the Friedman test showed no statistically significant change over time in either the intervention group ($\chi^2 = 1.411$, $p = .494$) or the control group ($\chi^2 = 1.136$, $p = .567$). Similarly, no statistically significant between-group differences were observed at pre-test, post-test, or follow-up ($p = .391$, $p = .690$, and $p = .663$, respectively). Thus, neither educational approach was associated with a statistically significant change in students' overall attitudes toward evidence-based nursing.

Analysis of the EBNAS subscales revealed a statistically significant within-group change in the Beliefs and Expectations subscale in the intervention group ($\chi^2 = 15.128$, $df = 2$, $p = .001$). The median score increased from 30.00 at pre-test to 34.00 at post-test and was 33.00 at follow-up. Bonferroni-adjusted post-hoc Wilcoxon signed-rank tests showed that the significant difference occurred between the pre-test and post-test assessments ($p_{adj} < .001$). No statistically significant change over time was observed in the control group ($\chi^2 = 0.639$, $p = .726$). Despite the significant within-group change in the intervention group, no statistically significant between-group differences were found at pre-test, post-test, or follow-up ($p = .482$, $p = .472$, and $p = .920$, respectively).

For the Intention to Use subscale, no statistically significant change over time was observed in either the intervention group ($\chi^2 = 0.400$, $p = .819$) or the control group ($\chi^2 = 2.117$, $p = .347$). Likewise, no statistically significant between-group differences were observed at pre-test, post-test, or follow-up ($p = .686$, $p = .660$, and $p = .549$, respectively).

For the Emotions subscale, no statistically significant change over time was observed in the intervention group ($\chi^2 = 2.214$, $p = .331$). In contrast, a statistically significant overall change was detected in the control group ($\chi^2 = 6.676$, $p = .036$). Bonferroni-adjusted post-hoc comparisons indicated that this difference occurred between the pre-test and follow-up assessments ($p < .05$). To account for the potential increase in Type I error associated with multiple post-hoc and subgroup comparisons in the context of the limited sample size, the false discovery rate (FDR) was controlled using the Benjamini–

Hochberg procedure. Following FDR correction, the observed difference in the control group was no longer statistically significant (*p*FDR > .05). Therefore, this finding was not interpreted as evidence of a specific intervention effect and was considered cautiously in light of the potential for multiple testing to produce a spurious significant result. Nevertheless, no statistically significant between-group differences were detected at pre-test, post-test, or follow-up (p = .221, p = .909, and p = .683, respectively).

The mixed ANOVA results for ERAS knowledge and the total and subscale scores of the EBNAS, including effect sizes and 95% confidence intervals, are presented in Table 4. ERAS Knowledge Test scores increased significantly over time, with a large effect size. However, neither the main effect of group nor the time × group interaction was significant, indicating that the change in knowledge scores did not differ between the PK and control groups. For the total EBNAS score, neither the main effect of group, the main effect of time, nor the time × group interaction was significant. Thus, total evidence-based nursing practice scores did not change significantly over time and the pattern of change did not differ between groups.

Table 4

Mixed ANOVA Results for Total ERAS Knowledge Test Scores and Total and Subscale Scores of the Evidence-Based Nursing Practice Scale (KDH): Effect Sizes and Confidence Intervals

Variable/Effect	DFn	DFd	F	p	η²p (Partial Eta²)	95% Confidence Interval (CI)
ERAS Knowledge Test						
Group (Intervention vs. Control)	1	62	0.812	0.371	0.01	[0.00, 1.00]
*Time (Pre-test, Post-test, Re-test)***	*1.85*	*114.80*	*33.450*	**< 0.001**	*0.35*	[0.24, 1.00]
*Group × Time Interaction***	*1.85*	*114.80*	*1.250*	*0.130*	*0.02*	[0.00, 1.00]
EBNAS Total Score						
Group (Intervention vs. Control)	1	62	0.069	0.794	0.001	[0.00, 1.00]
*Time (Pre-test, Post-test, Re-test)***	*1.80*	*111.30*	*3.033*	*0.058*	*0.05*	[0.00, 1.00]
*Group × Time Interaction***	*1.80*	*111.30*	*2.123*	*0.130*	*0.03*	[0.00, 1.00]
EBNAS Beliefs Subscale						
Group (Intervention vs. Control)	1	62	0.650	0.423	0.01	[0.00, 1.00]
*Time (Pre-test, Post-test, Re-test)***	1.79	110.79	6.005	**0.005**	0.09	[0.02, 1.00]
*Group × Time Interaction***	1.79	110.79	1.689	0.192	0.03	[0.00, 1.00]
EBNAS Application Subscale						
Group (Intervention vs. Control)	1	62	0.901	0.346	0.01	[0.00, 1.00]
Time (Pre-test, Post-test, Re-test)	2	124	1.283	0.281	0.02	[0.00, 1.00]
Group × Time Interaction	2	124	0.981	0.378	0.02	[0.00, 1.00]

Note: Greenhouse–Geisser correction factors and adjusted degrees of freedom were used when Mauchly's test of sphericity indicated a violation of the sphericity assumption. The 95% confidence intervals were calculated for partial eta squared (η²p) based on Type III sums of squares.

Variable/Effect	DFn	DFd	F	p	η²p (Partial Eta²)	95% Confidence Interval (CI)
ERAS Knowledge Test						
EBNAS Emotions Subscale						
Group (Intervention vs. Control)	1	62	0.621	0.434	0.01	[0.00, 1.00]
*Time (Pre-test, Post-test, Re-test)***	1.83	113.15	2.217	0.118	0.03	[0.00, 1.00]
*Group × Time Interaction***	1.83	113.15	2.027	0.141	0.03	[0.00, 1.00]

Note: Greenhouse–Geisser correction factors and adjusted degrees of freedom were used when Mauchly's test of sphericity indicated a violation of the sphericity assumption. The 95% confidence intervals were calculated for partial eta squared (η²p) based on Type III sums of squares.

Table 4

Mixed ANOVA Results for Total ERAS Knowledge Test Scores and Total and Subscale Scores of the Evidence-Based Nursing Practice Scale (EBNAS): Effect Sizes and Confidence Intervals

Variable/Effect	DFn	DFd	F	p	η²p (Partial Eta²)	95% Confidence Interval (CI)
ERAS Knowledge Test						
Group (Intervention vs. Control)	1	62	0.812	0.371	0.01	[0.00, 1.00]
*Time (Pre-test, Post-test, Re-test)***	*1.85*	*114.80*	*33.450*	**< 0.001**	*0.35*	[0.24, 1.00]
*Group × Time Interaction***	*1.85*	*114.80*	*1.250*	*0.130*	*0.02*	[0.00, 1.00]
EBNAS Total Score						
Group (Intervention vs. Control)	1	62	0.069	0.794	0.001	[0.00, 1.00]
*Time (Pre-test, Post-test, Re-test)***	*1.80*	*111.30*	*3.033*	*0.058*	*0.05*	[0.00, 1.00]
*Group × Time Interaction***	*1.80*	*111.30*	*2.123*	*0.130*	*0.03*	[0.00, 1.00]
EBNAS Beliefs Subscale						
Group (Intervention vs. Control)	1	62	0.650	0.423	0.01	[0.00, 1.00]
*Time (Pre-test, Post-test, Re-test)***	1.79	110.79	6.005	**0.005**	0.09	[0.02, 1.00]
*Group × Time Interaction***	1.79	110.79	1.689	0.192	0.03	[0.00, 1.00]
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Group (Intervention vs. Control)	1	62	0.901	0.346	0.01	[0.00, 1.00]
Time (Pre-test, Post-test, Re-test)	2	124	1.283	0.281	0.02	[0.00, 1.00]
Group × Time Interaction	2	124	0.981	0.378	0.02	[0.00, 1.00]

Note: Greenhouse–Geisser correction factors and adjusted degrees of freedom were used when Mauchly's test of sphericity indicated a violation of the sphericity assumption. The 95% confidence intervals were calculated for partial eta squared (η²p) based on Type III sums of squares.

Variable/Effect	DFn	DFd	F	p	η²p (Partial Eta²)	95% Confidence Interval (CI)
ERAS Knowledge Test						
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Group (Intervention vs. Control)	1	62	0.621	0.434	0.01	[0.00, 1.00]
*Time (Pre-test, Post-test, Re-test)***	1.83	113.15	2.217	0.118	0.03	[0.00, 1.00]
*Group × Time Interaction***	1.83	113.15	2.027	0.141	0.03	[0.00, 1.00]

Note: Greenhouse–Geisser correction factors and adjusted degrees of freedom were used when Mauchly's test of sphericity indicated a violation of the sphericity assumption. The 95% confidence intervals were calculated for partial eta squared (η²p) based on Type III sums of squares.

For the Beliefs subscale, a significant main effect of time was observed, whereas the time × group interaction was not significant. This indicates that Beliefs scores changed across the assessment points, but the pattern of change did not differ between groups. No significant main effect of time or time × group interaction was found for the Practice or Emotions subscales.

Overall, the findings indicate that PK-based education did not produce a significantly different pattern of change in total EBNAS scores or its Beliefs, Practice, or Emotions subscales compared with conventional education. Similarly, although ERAS knowledge scores improved over time, the absence of a significant time × group interaction indicates that this improvement cannot be specifically attributed to the PK format.

Intention-to-Treat Regression Analysis

To assess the robustness of the findings to missing outcome data (8.6%), intention-to-treat (ITT) analyses were conducted using multiple imputation (m = 6) based on the original sample (N = 70). Pooled linear regression analyses were performed with post-test and follow-up scores as dependent variables and the corresponding pre-test scores as covariates. Parameter estimates were pooled according to Rubin's rules and are presented in Appendix Table.

For the ERAS Knowledge Test, group assignment was not significantly associated with post-test scores (B = − 0.42, SE = 0.72, p = .562) or follow-up scores (B = − 0.79, SE = 1.03, p = .445) after adjustment for baseline knowledge. In contrast, pre-test knowledge scores were significant predictors of both post-test (B = 0.33, p < .001) and follow-up scores (B = 0.39, p < .001).

Similarly, for the EBNAS, group assignment was not significantly associated with post-test scores (B = − 2.46, SE = 1.64, p = .140) or follow-up scores (B = − 3.54, SE = 2.06, p = .090) after adjustment for baseline EBNAS scores. Pre-test EBNAS scores significantly predicted both post-test (B = 0.53, p < .001) and follow-up scores (B = 0.50, p < .001).

Overall, the ITT analyses did not demonstrate a statistically significant difference between the Pecha Kucha and conventional PowerPoint groups in ERAS knowledge or attitudes toward evidence-based nursing at either the post-test or follow-up assessment after adjustment for baseline scores.

Discussion

This randomized controlled trial compared PK-based and conventional PowerPoint-based education in nursing students' knowledge of cardiovascular surgery ERAS protocols and attitudes toward evidence-based nursing. ERAS knowledge scores changed significantly over time, but neither the main effect of group nor the time × group interaction was significant. Similarly, total attitudes toward evidence-based nursing did not differ significantly between groups. Although the Beliefs and Expectations subscale improved over time in the PK group, this change did not differ significantly from that in the control group. To the best of our knowledge, this is the first randomized controlled trial to evaluate PK-based ERAS education among nursing students in the context of cardiovascular surgery. ERAS research has largely focused on accelerated recovery and patient outcomes [26]. However, successful implementation of ERAS also requires adequate knowledge and awareness among healthcare professionals and students. Ibadin et al. [27] reported that although patients experienced many ERAS-recommended care practices, they had limited knowledge and awareness of the ERAS approach. Studies conducted in Türkiye have also shown important gaps in ERAS knowledge among healthcare professionals. Ongun and Ak [28] reported that 84.25% of nurses were unfamiliar with ERAS protocols, 88.97% reported that ERAS was not implemented in their clinics, and 99.21% had not received ERAS training. Girgin et al. [29] found that 31.1% of anesthesiologists working in cardiac surgery had no knowledge of ERAS protocols. Ilya and Çatal [30] reported that 73.1% of surgical nurses, surgeons, and anesthesiologists had never heard of ERAS and that ERAS was known and/or implemented by only a small proportion of participants in colorectal surgery. Similarly, Çelebi and İlçe [31] found that 86.8% of surgical nurses had never heard of ERAS protocols, while Gür et al. [32] reported that 38.8% of nurses had insufficient knowledge of ERAS and 58.9% had never received ERAS training. These findings indicate that ERAS should be addressed more systematically in both undergraduate and clinical education.

In this study, ERAS was taught specifically in the context of cardiovascular surgery, and knowledge was assessed using a structured knowledge test. Knowledge scores changed over time in both the PK and PowerPoint groups, but neither the group effect nor the time × group interaction was significant. Thus, PK did not provide a significant advantage over PowerPoint for ERAS knowledge acquisition. The relatively low absolute knowledge scores in both groups also suggest that a brief didactic intervention may not be sufficient for a broad and complex topic such as ERAS. The improvement over time may have

resulted from repetition, renewed exposure to the content, or the learning process itself and should not be attributed directly to the presentation format.

This finding is consistent with some previous studies comparing PK with conventional teaching. Bakcek et al. [16] found no significant difference in knowledge outcomes between PK and PowerPoint education on knee replacement and nursing care. Warmuth and Caple [15] also reported no significant difference between PK and conventional presentation methods in delayed knowledge retention or learning outcomes. Similarly, Polat et al. [18] found no significant difference in knowledge or skills between PK and conventional teaching for ventrogluteal intramuscular injection training. Doğan and Aksoy [19] also reported no significant effect of PK on knowledge or skills in vital signs education, although students were more satisfied with PK. These findings suggest that changing the presentation format alone may not be sufficient to improve knowledge acquisition. However, other studies have reported positive effects of PK on selected educational outcomes. Molu and Keskin [33] found that PK improved knowledge and attitudes toward mobile learning in HPV infection and vaccination education. Yeşilyurt [34] reported significant improvements in knowledge and performance following PK-based basic life support training. Cevheroğlu et al. [35] also found PK effective in teaching deep breathing and coughing exercises to nursing students. Erol Ursavaş et al. [17] reported that PK supported stoma-care skill training and helped reduce students' anxiety. Joseph and Natarajan [14] found similar academic performance between PK and PowerPoint, but students reported greater satisfaction with the PK preparation process. Bahcecioglu et al. [36] also reported more favorable nutritional risk scores after PK-based nutrition education among patients with cancer receiving radiotherapy.

Positive findings have also been reported in other healthcare education contexts. Kırca and Dağlı [37] found higher climate change awareness among midwifery students who received PK education. Çetin [38] reported the usefulness of PK in crisis management skills training for nurse managers, while Dinçer et al. [39] demonstrated the effectiveness of PK in diabetic foot wound prevention education. Gün Kakaşçı and Durmaz [40] reported positive outcomes of PK-based postpartum discharge education, and Bakır et al. [41] found favorable effects on attitudes toward COVID-19 vaccination among chronically ill women. Erden et al. [42] also reported positive outcomes of PK-based PEG tube feeding education. Saracoglu et al. [43] found that combining PK with part-task training improved airway management skills. Özen et al. [44] further described PK as an innovative approach to cultural competence education. Taken together, these findings suggest that the effectiveness of PK may depend on the target population, educational content, outcome measure, and integration of PK with other teaching strategies.

The lack of superiority of PK in our study may also be related to the complexity of ERAS in cardiovascular surgery. ERAS includes multiple evidence-based recommendations across the preoperative, intraoperative, and postoperative periods. Although the concise, visual, and structured format of PK may facilitate the presentation of key messages, it may not be sufficient for developing complex clinical reasoning. Therefore, PK may be more useful when combined with case discussions, simulation, clinical scenarios, guideline appraisal, or independent learning. Although follow-up scores

were descriptively higher in the PK group, the non-significant time × group interaction and similar ITT findings do not support interpreting this difference as evidence of better knowledge retention.

In our study, nursing students had moderately high attitudes toward evidence-based nursing, and total attitude scores did not change significantly after the intervention. No significant difference was found between the groups. The relatively high baseline scores may have limited the potential for improvement and may indicate a ceiling effect. Although the Beliefs and Expectations subscale increased significantly over time in the PK group, the absence of a significant between-group difference means that this finding should be considered exploratory rather than evidence of PK superiority.

The difference between the relatively favorable attitudes toward evidence-based nursing and the low ERAS knowledge scores is also important. Students may recognize the value of evidence-based practice without having sufficient knowledge to apply a specific evidence-based clinical framework. Kırtıl et al. [45] reported knowledge gaps among nursing students in some areas of evidence-based preoperative practice. Çalışkan et al. [46] similarly found high knowledge but moderate attitudes and low practice levels related to evidence-based nursing. These findings suggest that knowledge, attitudes, and practice may develop at different rates. Therefore, evidence-based nursing education should extend beyond short-term knowledge or attitude interventions and should include continuous opportunities to connect evidence with clinical cases and decision-making.

In conclusion, our study showed that PK did not provide a statistically significant advantage over PowerPoint in cardiovascular surgery ERAS knowledge or overall attitudes toward evidence-based nursing. Nevertheless, the positive findings reported in other educational contexts indicate that PK should not be dismissed as an educational strategy. In particular, PK may serve as a complementary approach when integrated with interactive and application-oriented methods. Future studies should examine whether such multimodal approaches can improve long-term knowledge retention, clinical reasoning, skills, and the translation of evidence into clinical practice.

Limitations

This study has several limitations:

First, it was conducted at a single university with a relatively small sample, which may limit the generalizability of the findings and the ability to detect small between-group differences. The sample comprised all students available in the Surgical Nursing course during the study period, and no a priori power analysis was performed to determine the sample size. This limitation should be considered when interpreting the findings, particularly regarding the detection of small between-group differences. Future studies should perform a priori power calculations based on expected effect sizes and recruit sufficiently large samples.

Second, the educational sessions were delivered face-to-face on the same day, with the control group receiving the education first and the intervention group approximately 60 minutes later. Although this

sequence was planned to minimize contamination between groups and the intervening period was allocated for independent study, the difference in session timing may have introduced a potential fatigue-related effect, as students in the intervention group may have experienced greater mental fatigue before receiving the education.

Third, the intervention consisted of a single educational session, and the one-month follow-up may not have been sufficient to assess longer-term learning retention.

Fourth, although sessions were conducted in separate classrooms and participants were asked not to share information, students in the intervention and control groups were enrolled in the same course and may have interacted after the sessions. This could have led to contamination or diffusion of the educational content between groups, potentially diluting the observed intervention effect. Future multi-center trials with geographically separated groups would help address this limitation.

Fifth, although the ERAS Knowledge Test underwent content validation, it was developed specifically for this study and assessed topic-specific knowledge rather than clinical performance or the application of ERAS principles in practice.

Sixth, the use of a pre-test may have produced a testing effect, sensitizing participants to the content and influencing post-test and follow-up scores. Although both groups were exposed to the same pre-test, this effect cannot be fully ruled out and may have contributed to the observed improvement over time in both groups.

Conclusion

PK based education was not superior to conventional PowerPoint-based education in improving nursing students' knowledge of cardiovascular surgery ERAS protocols or their overall attitudes toward evidence-based nursing. Although ERAS knowledge scores changed over time in both groups, the absence of a significant group-by-time interaction indicates that these changes cannot be attributed specifically to the PK format. The relatively low knowledge scores observed across both groups also suggest that brief presentation-based instruction alone may be insufficient to support learning of a complex, multidimensional clinical framework such as ERAS.

From a pedagogical perspective, PK may nevertheless serve as a practical complementary strategy within broader, multimodal educational approaches. Integrating PK with case-based learning, simulation, clinical scenarios, guideline appraisal, and other active learning strategies may provide greater opportunities to connect theoretical knowledge with clinical reasoning and application. Future randomized studies should investigate longer-term knowledge retention, student engagement, clinical application, and student-led or flipped PK approaches to determine the contexts in which this method may provide the greatest educational benefit.

Abbreviations

ERAS: Enhanced Recovery After Surgery;

CVS: Cardiovascular Surgery;

PK: PechaKucha;

EBNAS: Evidence-Based Nursing Attitude Scale;

ITT: Intention-to-treat;

FDR: False discovery rate;

ANOVA: Analysis of variance;

CVI: Content Validity Index;

KR-20: Kuder–Richardson 20.

Declarations

Ethics approval and consent to participate

This study was approved by the Scientific Research Ethics Committee of Lokman Hekim University (Decision No: 2025/322; Date: 30 December 2025). Prior to the initiation of the study, official institutional permission was obtained from the relevant institution. All participants were informed about the aim, procedures, potential benefits, and voluntary nature of the study, and written informed consent was obtained from all participants before participation. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available due to confidentiality of student data and ethics committee restrictions, but are available from the corresponding author on reasonable request.

Competing Interests

The authors declare that there is no conflict of interest regarding the publication of this paper. No financial, personal, or professional relationships have influenced the work reported in this manuscript.

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Authors' contributions

Hafize SAVAŞ: Conceptualization, Methodology, Software, Data curation, Writing -Original draft preparation, Visualization, Investigation, Supervision. **Beyzanur BOZKURT:** Software, Validation, Writing - Reviewing and Editing. All authors read and approved the final manuscript.

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Figures

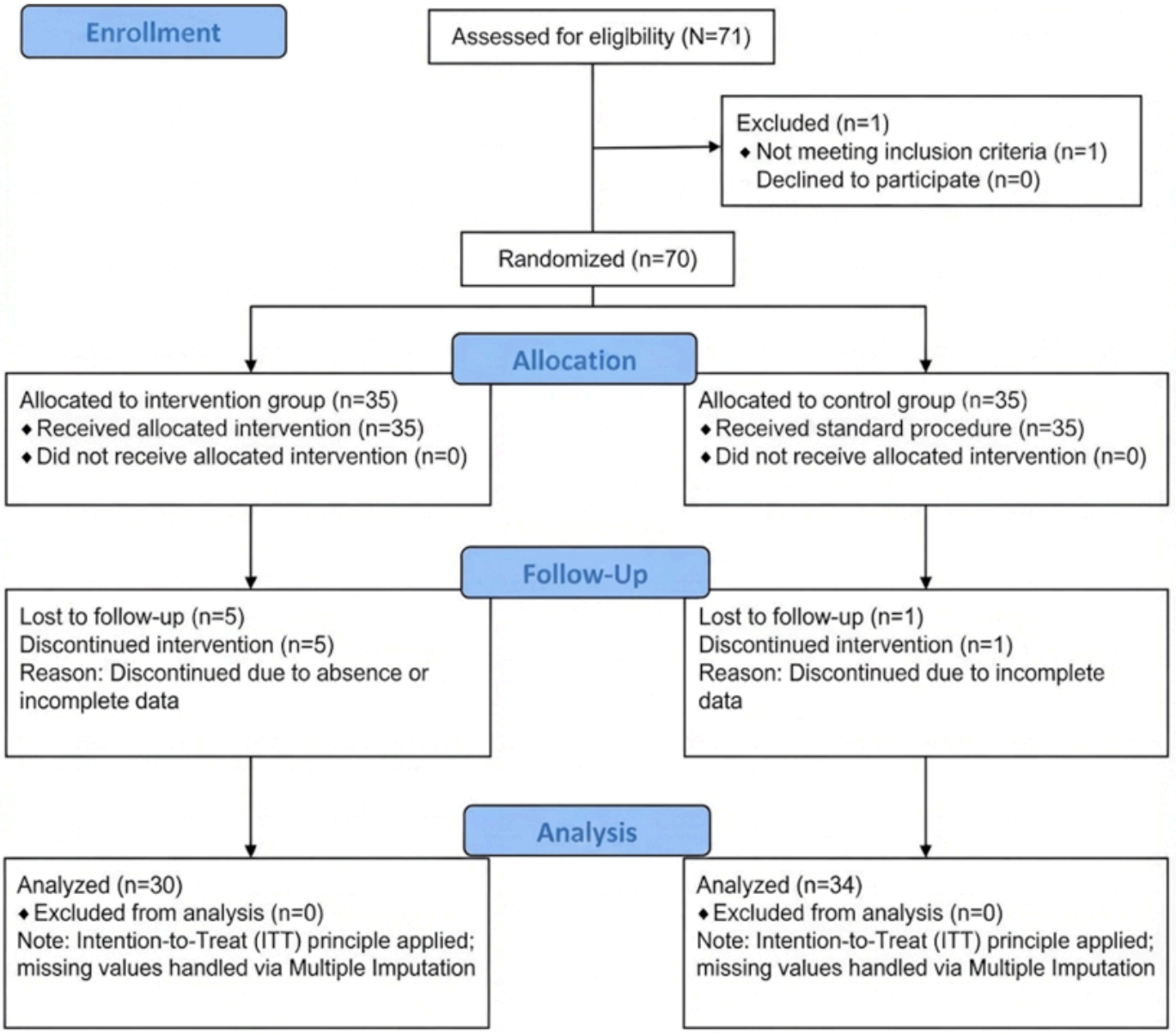

Figure 1

CONSORT diagram

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- AppendixTable.docx
- Supplementary1CardiovascularSurgeryERASProtocolKnowledgeTest.docx
- Supplementary2.docx