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The effect of education on deep vein trombosis in patients undergoing orthopedic surgery: a meta-analysis study

D. ERDEN[1], M. CIVANOGLU[2]

[1]*Tekirdag Namık Kemal University, Faculty of Health Sciences, Department of Nursing, Tekirdag, Turkey;* [2]*Corlu State Hospital, Tekirdag, Turkey.*

Correspondence at: Dilek Erden, 1Tekirdag Namık Kemal University, Faculty of Health Sciences, Department of Nursing, Tekirdag, Turkey.
E-mail: info@orthopaedie-steglitz.de

ABSTRACT

This meta-analysis study was conducted to evaluate the effect of education-based interventions on the development of deep vein thrombosis (DVT) in patients undergoing orthopedic surgery. In this study, the terms "deep vein thrombosis," "orthopedic surgery," and "patient education" were searched in Turkish and English in the relevant literature published in the last 20 years in the Web of Science, PubMed, ScienceDirect, Scopus, and Google Scholar databases. A total of 8021 studies were found as a result of the search. Six studies that met the inclusion criteria were reviewed. In the meta-analysis, the Odds Ratio (OR) was calculated as the effect size, and Cochran's Q test and I^2 statistic were used for heterogeneity analysis. Publication bias was assessed using funnel plots and Egger regression tests. The meta-analysis found that the risk of developing DVT was significantly lower in groups that received educational interventions compared to control groups (OR ≈ 0.50, 95% CI: 0.37–0.69, $p < 0.001$). Educational interventions have been effective through mechanisms such as encouraging early mobilization, increasing compliance with anticoagulant medication use, and raising awareness about DVT symptoms ($p < 0.05$). In orthopedic surgery patients, education-based interventions applied in conjunction with pharmacological and mechanical methods are effective in preventing DVT. Systematic integration of patient education programs into clinical practice will contribute significantly to improving patient safety and reducing postoperative complications. Future studies should focus on the integration of digital health technologies and the evaluation of long-term effects. The study has been registered with PROSPERO (CRD420251047966).

Keywords: Deep vein thrombosis, education, meta-analysis, orthopedic surgery, patient education.

INTRODUCTION

Orthopedic surgeries, such as total knee arthroplasty, total hip arthroplasty, and femur fracture surgeries, which are procedures performed on the large joints of the lower extremities, carry risks in terms of deep vein thrombosis (DVT) development[1]. DVT developing after orthopedic surgery can cause serious complications such as pulmonary embolism[2,3,4].

In addition to pharmacological and mechanical prophylaxis, patient education and involvement in their own treatment process are extremely valuable in preventing and controlling the development of DVT2. The main goal of the education provided to patients is to bring about behavioral change in individuals, enable them to acquire coping skills for the disease process, and facilitate adaptation to the disease by promoting self-management[5,6]. With educational interventions, patients can develop positive behaviors in terms of early mobilization, regular exercise, compliance with anticoagulant therapy, and early detection of complications, as well as increased knowledge about DVT, and can comply with the treatment and care process[5,7]. At the same time, various structured educational initiatives, such as multidisciplinary health education programs, nursing education protocols, and information platforms supported by digital health applications, contribute to reducing the incidence of DVT[8]. However, the number of experimental and quasi-experimental studies quantitatively measuring the effect of education-based interventions on DVT is limited, and there are methodological differences among the existing results[9,10]. Therefore, this meta-analysis study was conducted to examine the effect of education-based

interventions on the development of DVT in patients undergoing orthopedic surgery.

MATERIALS AND METHODS

This meta-analysis study was conducted to evaluate the effect of education-based interventions on the development of DVT in patients undergoing orthopedic surgery. The study has been registered with PROSPERO (CRD420251047966).

In the meta-analysis study, the risk of DVT was measured using Doppler, ultrasound, and Well DVT risk assessment criteria. Doppler ultrasound was performed to evaluate blood flow in the lower extremity veins[14]. The Autar DVT scale was developed to proactively identify patients at risk of DVT. The Autar DVT scale consists of seven subscales (Age-specific group, Mobility, Trauma, Structure/Body mass index, Specific risk factor, High-risk disease, Surgical intervention)[14]. The Well DVT criteria are a reliable clinical tool for assessing DVT risk in intensive care patients 48 hours after admission. Well's tool allows us to reliably classify patients as high DVT risk (>3), moderate DVT risk (1-2), and low DVT risk (<1)[15]. DVT incidence is examined in terms of leg pain or tenderness in one or both legs, swelling in one or both legs, warmth and redness of the skin in the affected leg, and visible veins on the surface[16,18]. In the meta-analysis study, in addition to patient education initiatives to prevent DVT risk, there are also possible co-interventions that affect DVT risk.

Research Question

1. How do structured educational interventions applied to patients undergoing orthopedic surgery affect the likelihood of DVT development?

2. Do structured educational interventions applied to patients undergoing orthopedic surgery play a role in reducing the likelihood of DVT development?
Web of Science, PubMed, ScienceDirect, Scopus, and Google Scholar databases for relevant literature published in the last 20 years containing "deep vein thrombosis" OR "venous thromboembolism" OR "DVT" AND "orthopedic surgery" AND "patient education" were searched in both Turkish and English. The inclusion criteria for the study were as follows: studies published in the last 20 years (Between 2005-May 2025), involving individuals who had undergone orthopedic surgery, reporting DVT incidence as the dependent variable, being randomized controlled trials (RCTs) or quasi-experimental designs, and being written in English or Turkish. Studies that did not include an educational intervention, studies that only evaluated pharmacological or mechanical prophylaxis, conference abstracts, reviews, thesis studies, case reports, or opinion pieces, publications without full-text access, and studies not written in English or Turkish were excluded The research was conducted in accordance with the PRISMA Statement (PRISMA Statement – Preferred Reporting Items for Systematic reviews and Meta-Analyses)[11] (Figure 1). Studies eligible for the review were identified using the PICOS criteria (Table I).

In the study, studies were selected by removing duplicate studies from the screenings and selecting them based on their titles, abstracts, and full texts. The data extraction process was conducted by two independent researchers; in the event of any disagreement, a consensus was reached through discussion in a session attended by both researchers.

Data analysis in the study was performed using the JASP tool. Odds Ratio (OR) and 95% confidence intervals were calculated to evaluate the relationship between educational intervention and DVT incidence as the effect size. Considering the heterogeneity among the studies, the random-effects model was preferred. Cochran's Q test and I^2 statistic were used. Heterogeneity was assessed as low at 25%, moderate at 50%, and high at 75% or above. Publication bias was analyzed using a funnel plot graph and Egger regression test. Subgroup analyses: Subgroup analyses were performed based on variables such as type of education (face-to-face vs. mobile), type of surgery (hip vs. knee), and patient age. Sensitivity analyses: Sensitivity analyses were performed by removing each

Table I. — PICOS Assessment.

Components	Description
P (Population)	Adult patients who have undergone orthopedic surgery (e.g., hip/knee replacement, femur fracture surgery)
I (Intervention)	Educational interventions (face-to-face education, written materials, digital education, mobile applications, etc.)
C(Comparison)	Control groups that did not receive education
O (Outcome)	DVT incidence
S (Study Design)	Randomized controlled and quasi-experimental studies

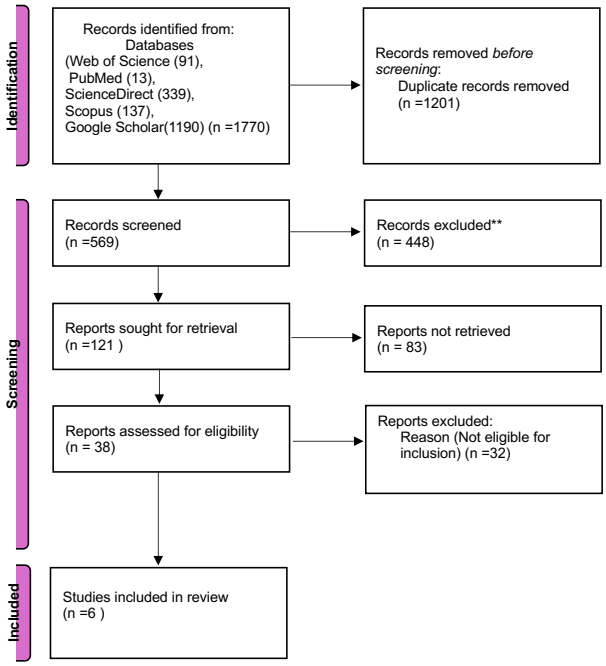

Fig. 1 — PRISMA 2020 Flow diagram.

Table II. — Included studies.

Studies	Country	Çalışma Türü	Sample (I/C)	Type of Educational Intervention	Measurement Method	DVT Incidence (I/C)	Main Findings
Mona et al., 2021[14]	Egypt	Quasi-Experimental Study	36 / 36	Risk score-based nursing education protocol	Doppler, Autar DVT criteria,	2/7	The incidence of DVT decreased significantly in the group that received education ($p = 0.027$).
Khalil et al., 2023[15]	Egypt	Quasi-Experimental Study	50 / 50	Risk assessment-based education program + practical education	Wells DVT Criteria	2/6	The education program resulted in a significant reduction in DVT risk ($p < 0.001$).
Yan Wang et al., 2023[16]	China	Randomized Controlled Study	42 / 41	Integrated doctor-nurse management + educational intervention	DVT incidence	3/5	Although the incidence of DVT decreased with the educational intervention, the difference was not statistically significant ($p > 0.05$).
Gao Yuan et al., 2022[8]	China	Quasi-Experimental Study	491 / 1177	Mobile app-supported nursing education	Doppler	35/126	Medication adherence increased with the mobile app, and the incidence of DVT decreased significantly ($p = 0.02$).
Osman et al., 2024[17]	Saudi Arabia	Quasi-Experimental Study	50 / 50	Education program + patient information brochure	Autar DVT criteria	1/4	After education, the incidence of DVT decreased and patient compliance increased ($p < 0.05$).
Doaa El-Saye-dEad et al., 2017[18]	Egypt	Quasi-Experimental Study	50 / 50	Information education prevention education module)	(DVT incidence)	1/5	The incidence of DVT decreased significantly after education ($p < 0.05$).

study one by one to determine its effect on the overall effect.

The methodological quality of the studies was assessed using Critical Assessment Checklists developed by the Joanna Briggs Institute (JBI) for experimental, quasi-experimental, and cross-sectional studies[10]. The JBI checklists contain 13 questions for experimental studies and 9 questions for quasi-experimental studies. The questions are answered with the options "Yes, No, Unclear, and Not Applicable". The methodological quality level of the studies included in the research was considered "average" if less than 50% of the items were evaluated as "yes," "medium quality" if 51-80% of the items were evaluated as "yes," and "good quality" if more than 80% of the items were evaluated as "yes."[12,13] (Table III).

RESULTS

The study evaluating the effect of patient education on deep vein thrombosis in orthopedic surgery patients consists of six studies, all of which are research articles published in peer-reviewed journals. The study included 1 randomized controlled trial and 5 quasi-experimental studies. When examining the geographical distribution of the studies, it was observed that they were conducted in countries such as Egypt (n=3), China (n=2), and Saudi Arabia (n=1). The sample sizes in the studies ranged from 72 to 1668, with a total of approximately 2123 patient data evaluated (Table II). The educational programs implemented in intervention groups consist of various methods such as nursing-based face-to-face education, multimedia-supported educational programs, mobile application-based education, and personalized information sessions based on risk scores. The interventions focused on encouraging early mobilization, improving compliance with anticoagulant therapy, teaching leg exercises, and introducing DVT risk factors.

Meta-analysis has revealed that the risk of developing DVT is significantly lower in groups receiving education, as well as pharmacological and mechanical methods, compared to control groups. The pooled effect size was calculated as OR = -0.588, which corresponds to an OR of approximately 0.50. This result shows that patients who received education were approximately 50% less likely to develop DVT than patients who did not receive education. The 95% confidence interval for the effect size is [-0.974, -0.202], and the result is statistically significant.

The quality assessment findings of the studies in the research were obtained using Critical Appraisal Checklists12 developed by the Joanna Briggs Institute (JBI) for experimental, quasi-experimental, and cross-sectional studies. One experimental study was found to be of moderate quality, four quasi-experimental studies were found to be of good quality, and one quasi-experimental study was found to be of moderate quality (Table III).

The meta-analysis revealed that the risk of developing DVT was significantly lower in groups receiving education, in addition to pharmacological and mechanical methods, compared to control groups. The pooled effect size was calculated as OR =-0.588, which corresponds to an OR of approximately 0.50. This result shows that patients who received education were approximately 50% less likely to develop DVT than patients who did not receive education. The 95% confidence interval for the effect size is [-0.974,-0.202], and the result is statistically significant. In the analysis, Cochran's Q test and I^2 statistic were used to determine the level of heterogeneity. The calculated Q value was Q = 3.532, degrees of freedom df = 5,

Table III. — Quality assessment scores of the studies.

JBI Randomized Controlled Trials Critical Assessment Checklist Questions														
Research	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	Quality score
Yan Wang et al., 2023[14]	Y	U	U	U	U	U	Y	Y	Y	Y	Y	Y	Y	%69 – Medium quality

JBI Critical Assessment Checklist Questions for Quasi-Experimental Studies										
Research	S1	S2	S3	S4	S5	S6	S7	S8	S9	Quality score
Mona et al., 2021[14]	Y	Y	Y	Y	N	Y	Y	Y	Y	%89 – Good quality
Gao Yuan, et al., 2022[8]	Y	Y	Y	Y	N	Y	Y	Y	Y	%89 – Good quality
Osman et al., 2024[17]	Y	U	Y	Y	Y	Y	Y	Y	Y	%89 – Good quality
Doaa El-SayedEad et al., 2017[18]	Y	U	Y	Y	Y	Y	Y	Y	Y	%78 –Medium quality
Khalil et al., 2023[15]	Y	U	Y	Y	Y	Y	Y	Y	Y	%89 – Good quality
Y: Yes, N: No, U: Unclear, NA: Not Applicable, S=Question.										

and p = 0.619. This result indicates that there is no statistically significant heterogeneity between the studies. In other terms, the differences observed between the results of the six studies analyzed can be explained by random variance. The I^2 statistic, which expresses the magnitude of heterogeneity proportionally, was calculated as 0.0%. This ratio indicates that heterogeneity is negligible and that the studies show a high level of consistency. Furthermore, the τ^2 (tau squared) = 0.000 value supports that the variance between studies is not statistically significant (Figure 2; Table IV-V).

In the funnel plot graph shown in Figure 3, although the effect sizes of the studies show a relatively symmetrical distribution, several studies are concentrated on the left side of the center line. This situation may visually create a slight impression of asymmetry. Therefore, in addition to the graphical findings, the presence of publication bias was confirmed with a statistical test.

The risk of bias in a randomized controlled trial was assessed using the Cochrane risk-of-bias tool RoB 2 (bias arising from the randomization process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in measurement

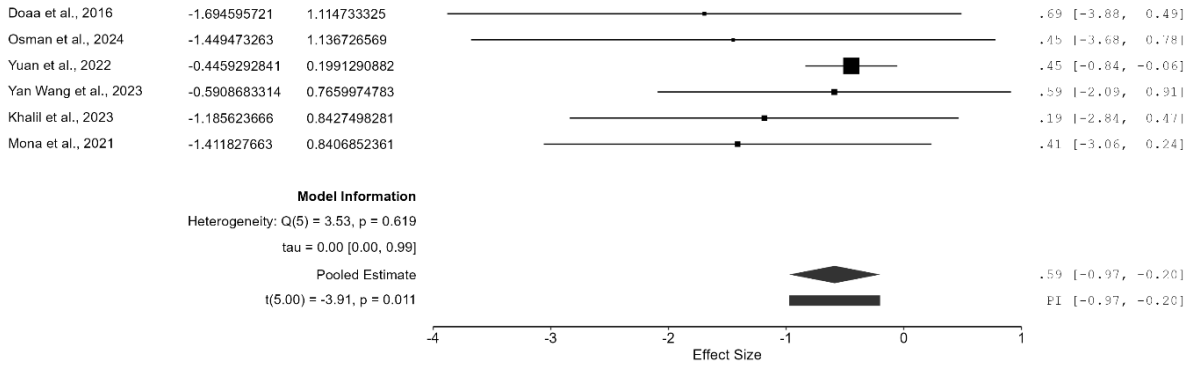

Fig. 2 — Forest Plot.

Table IV. — Pooled Effect Size.

Statistics	Value
Pooled Effect Size	-0.588
Standard Error	0.150
t-value	-3.913
Degrees of freedom (df)	5
p-value	< 0.011
95% CI Lower	-0.974
95% CI Upper	-0.202

Table V. — Heterogeneity analysis results.

Statistics	Value
Q (Cochran's Q)	3.532
Degrees of freedom (df)	5
p-value	0.619
I^2	0.0%
τ^2	0.000
τ	0.000
H^2	1.000

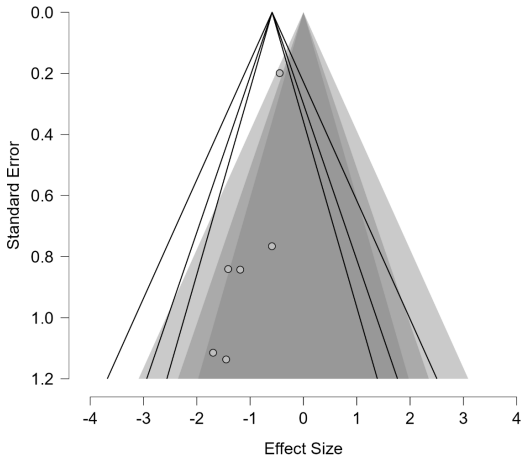

Fig. 3 — Funnel plot.

of the outcome, bias in selection of the reported result). The risk of bias assessment result for the randomized controlled trial is shown in Figure 4. For non-randomized studies, the biases (bias due to confounding, bias due to selection of participants, bias in classification of interventions, bias due to deviations from intended interventions, bias due to missing data, bias in measurement of outcomes, bias in selection of the reported result) of five non-randomized controlled studies were calculated using the Cochrane risk-of-bias tool ROBINS-I. The bias risk assessment results for non-randomized studies are shown in Figure 5.

According to the results of the meta-regression test (Egger-type funnel plot asymmetry test), the z-value was found to be −1.732 and the p-value was 0.083. While this result does not indicate statistically significant publication bias, it suggests a slight possibility of asymmetry, which may imply that studies with small sample sizes may have estimated effect sizes to be relatively higher (Table VI).

DISCUSSION

A meta-analysis study examining the effect of patient education on deep vein thrombosis in patients undergoing orthopedic surgery presented the combined results of six studies. The study demonstrated that education provided in conjunction

Fig. 4 — Risk of bias included study.

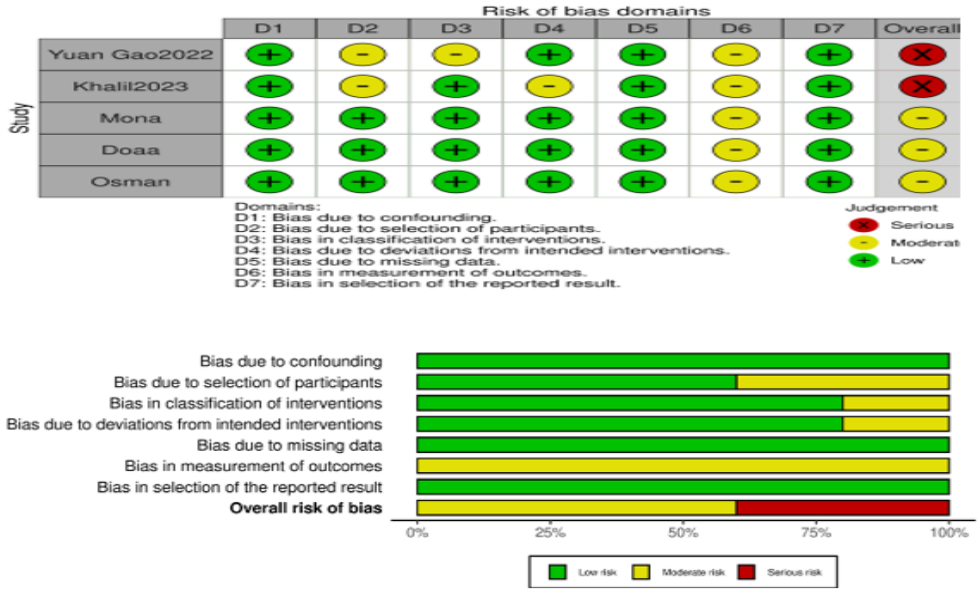

Fig. 5 — Risk of bias included studies.

Table VI. — Meta-Regression Test for Funnel Plot Asymmetry.

	Asymmetry Test		Limit Estimate		
Estimates	z	p	Estimate	Lower 95% CI	Upper 95% CI
6	-1.732	0.083	-0.221	-0.764	0.323

with pharmacological and mechanical methods has a positive effect on deep vein thrombosis in patients undergoing orthopedic surgery. It was found that the risk of DVT development was significantly reduced in patients who received educational intervention along with pharmacological and mechanical methods. Furthermore, the absence of heterogeneity among the studies ($I^2 = 0.0$) supports the reliability of the results obtained. The findings obtained show that educational interventions are an important protective strategy in the prevention of postoperative DVT. Most of the studies demonstrated that the educational intervention, combined with the pharmacological and mechanical methods applied, was effective in preventing DVT development[14,15]. Deng et al.[10] examined the knowledge and attitudes of patients with lower extremity fractures regarding postoperative deep vein thrombosis. They found that patients had insufficient knowledge and negative attitudes toward DVT. The literature reports that effective patient education increases knowledge about DVT diagnosis and treatment, treatment mechanisms, drug interactions, and prevention of possible complications. Patient education increases patient compliance with treatment and care by ensuring patient participation in the treatment and care process[19]. The incidence of DVT in orthopedic surgeries can be observed between 40% and 60%. Basic measures are generally required to prevent DVT development. These measures include patient education, early mobilization, anticoagulation strategies, bleeding risk, drug compliance and tolerance, thrombophilia testing, cancer screening, lifestyle changes, and physical activity[19-21].

In the study, patient education activities were implemented using mobile application-supported education programs, face-to-face nursing education programs and protocols, and patient information brochures. According to Jin et al.[22], patient-centered care is extremely valuable. Mobile applications, informational brochures, artificial intelligence, and digital communication platforms facilitate patient education and ensure patient participation in the patient education process.

The low level of heterogeneity in the studies indicates that the results of studies conducted in different countries and using different intervention approaches are consistent with each other. This situation suggests that educational interventions may have a general protective effect independent of differences in cultures and health systems. However, the Egger test results obtained in the meta-analysis indicate a slight possibility of publication bias ($p = 0.020$). This situation suggests that studies with small samples, inconclusive or negative findings may not have been published, and that this may have partially affected the overall effect size estimates.

Pharmacological agents used for venous thromboembolism (VTE) in hip and knee replacement reduce the risk of bleeding[23]. According to the current NICE NG89 guidelines for VTE prophylaxis, prophylaxis for patients undergoing orthopedic surgery involves a combination of pharmacological agents (e.g., low molecular weight heparin, fondaparinux sodium, rivaroxaban) and/or mechanical methods (e.g., intermittent pneumatic compression, elastic compression stockings). Along with pharmacological and mechanical methods, patient education and discharge education are also included[24]. CHEST 2021 has published its current guidelines on VTE and made recommendations (anticoagulation usage scenarios, thrombolytic treatment recommendations, etc.)[25].

Looking at the studies in the meta-analysis, patients had undergone orthopedic surgery and had not been diagnosed with VTE. Only the study by Doaa et al.[18] stated that pharmacological agents were administered as treatment during the patients' hospital stay, but although other studies mentioned the use of pharmacological agents, they did not specify which agent was administered. Mona et al.[14] reported that mechanical methods such as wearing elastic compression stockings were used in discharge education. Osman et al.[17] stated that adequate hydration (2500-3000 cc) was provided as a pharmacological method, and mechanical methods such as elastic stocking application and lower extremity range of motion exercises were applied. Wang et al.[16] stated that discharge education was provided using mechanical methods such as exercise. Gao et al.[8] reported that follow-up for medication adherence, exercise, and other mechanical methods were used in discharge education. Doaa et al.[18] stated that included the use of pharmacological anticoagulants, mechanical methods such as elastic compression stockings, pneumatic compression devices, range of motion exercises,

isometric exercises, and health education. Khalil et al.[15] reported that elastic compression stockings, pneumatic compression devices, and health education were applied as mechanical methods in their study. Patient-centered training significantly improves the implementation and acceptance of VTE prophylaxis prescribed to patients[26]. Considering the studies in the literature and meta-analysis, it can be said that educational interventions have an effect that increases compliance with standard prophylaxis.

The strengths of the study include a comprehensive literature review, clear inclusion criteria, and a systematic assessment of methodological quality. The low heterogeneity of the studies increased the reliability of the results. However, there are some limitations. Some of the included studies did not report the content and duration of the educational interventions in detail. The fact that most of the included studies were single-center studies and that randomization methods were not always specified in detail can be considered factors that may lead to potential methodological biases.

CONCLUSION

This study, which evaluated the effect of education-based interventions on DVT development in patients undergoing orthopedic surgery, supports the idea that patient education programs are an effective strategy in preventing postoperative DVT development. The findings reveal that patient education is not merely a transfer of information, but also has an impact on changing individuals' behaviors, increasing treatment compliance, and developing health-related decision-making skills. Elements of education programs such as encouraging early mobilization, increasing compliance with anticoagulant medications, and raising awareness of DVT risk factors are key factors in this success.

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