


The Effect of Foot Care Education for Patients with Diabetes on Knowledge, Self-Efficacy and Behavior: Systematic Review and Meta-Analysis

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Abstract

This systematic review and meta-analysis aimed to synthesize randomized controlled trials on the impact of foot care education on knowledge, self-efficacy and behavior in patients with diabetes. A search was made using PubMed, Web of Science, Science Direct, Google Scholar, YOK National Thesis Center and Google Scholar electronic databases for studies published between March 2003-January 2022. The search medical subject headings (MeSH) terms were diabetic foot, knowledge, self-efficacy, and behavior. Studies suitable for the systematic review and the meta-analysis met the following criteria (PICOS): target participants would be diagnosed with diabetes (population), diabetic foot education (intervention), comparison of the group receiving diabetic foot care education and routine care education, and the control group receiving only routine care education (comparison), studies evaluating the levels of knowledge, self-efficacy and behavior (outcome), randomized controlled trials (study design). Twenty-six studies were included in systematic review. Three studies for knowledge, 5 studies for behavior, 8 studies for self-efficacy were included in the meta-analysis (total sample: 2534, experiment: 1464, control: 1071). All of the studies had low reporting bias. The mean duration of educations for knowledge was 5.2 months. This duration was 4.8 months for behavior and 4.5 months for self-efficacy. In the random effect (since the homogeneity test: $P < .001$, this model was used), there were significantly difference in terms of knowledge (standardized mean difference (SMD): 1.656, 95% [CI]: 1.014-2.299, $P < .001$), and behavior (SMD: 1.045, 95% CI: 0.849-1.242, $P < .001$). But no difference was observed in terms of self-efficacy (SMD: 0.557, 95%CI: -0.402-1.517, $P > .05$). The results of a systematic review of twenty-six studies and a meta-analysis of 9 studies showed that diabetic foot education improved the level of knowledge and behavior of patients with diabetes, while not affecting their self-efficacy. Educational interventions with long-term follow-up are needed to address the growing health care needs of patients with diabetes.

Keywords

diabetes, diabetic foot, knowledge, self-efficacy, behavior, systematic review and meta-analysis

Introduction

Diabetes is one of the biggest global health problems of the 21st century.¹ The International Diabetes Federation (IDF) reported that approximately 463 million people between the ages of 20 and 79 had diabetes all over the world in 2019.¹ Uncontrolled diabetes is an important cause of mortality and morbidity, causing microvascular and macrovascular complications.¹⁻³ Diabetic foot is one of the most serious and common complications of diabetes.⁴ Every diabetic person has a 12-25% risk of developing a diabetic foot ulcers during their lifetime,⁵ 40-60% of non-traumatic lower limb amputations are performed due to diabetic foot ulcers.^{6,7} Diabetic foot wounds, besides the risk of amputation, lead to increased morbidity, impaired glucose control,

decreased quality of life (QOL) of patients, and high treatment costs.^{7,8} The average annual cost of diabetic foot per patient is 14 times the annual health expense per person in our country.⁹

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The complications of diabetes can be controlled by increasing the self-care capacity of people with diabetes and changing their lifestyle.¹⁰ It is important to provide patients with structured and comprehensive diabetic foot education. Studies where interventions were conducted to boost the self-sufficiency of patients with type 2 diabetes reported improvements in the self-care activities of patients and a decrease in hospitalization and emergency admissions.^{11,12} Considering the real-world data, it has been determined that individuals with diabetes lack important behaviors in terms of foot care,^{11,13} and even if they have sufficient knowledge about foot care they have difficulties in putting it into practice.¹⁴ It is important for individuals with diabetes to take the required responsibility for foot health, to be active and to make the right decisions about foot health. Patient trainings planned should be able to improve the knowledge, self-efficacy, and behaviors of individuals.¹⁵

Right knowledge, self-efficacy and behaviors are crucial factors in preventing foot wounds.¹⁶ It was stated that diabetic foot wounds and amputations can be reduced by 85% with a good foot care education and a multidisciplinary team approach.¹⁷ It is emphasized in 2015 guidelines of International Working Group on the Diabetic Foot (IWGDF) that it is necessary to provide preventive foot care education to the group under risk and to design this education as beneficial, cost-effective and efficient in clinical picture of the patient.¹⁰ Society for Vascular Surgery, American Podiatric Medical Association and the Society for Vascular Medicine state that new scientific studies, in which many approaches are combined and which might lead to change in behaviors and knowledge regarding foot care, are necessary.¹⁸ The significance of providing trainings that will support patients in terms of cognitive, affective, and psychomotor aspects regarding prevention of diabetic foot is supported by many studies in the literature. In order to examine the factors that will prevent diabetic foot formation in a broad framework, effect size analyzes are needed, which evaluate the effect of the trainings given in these three domains.

This study aimed to synthesize randomized controlled trials on the impact of foot care education on knowledge, self-efficacy and behavior in patients with diabetes in randomized controlled trials.

Methods

In this study, conducted to synthesize randomized controlled trials examining the effect of education provided to patients with diabetes regarding foot care on their knowledge, self-efficacy and behavior, PRISMA Statement (checklist items pertaining to the content of a systematic review and meta-analysis) was followed in creating the protocol and forming the article.^{19,20}

Before starting the study, all three participating researchers had an exchange of views regarding all these stages, and a common road map was determined. The review was registered in the International Prospective Register of Systematic Reviews (PROSPERO) Registry CRD42021225426.

Eligibility Criteria

Publications in English were included in the study. Studies were conducted by the first and the second researchers independently using PICOS elements based on inclusion and exclusion criteria. Studies suitable for the systematic review and the meta-analysis met the following criteria (PICOS):

Population: Target participants would be diagnosed with diabetes

Intervention: Diabetic foot education

Comparison: Comparison of the group receiving diabetic foot care education and routine care education, and the control group receiving only routine care education

Outcomes: Studies evaluating the levels of knowledge, self-efficacy and behavior

Study Design: Randomized controlled trials

Studies on diabetic foot care, which did not meet the inclusion criteria, were excluded from the study. Also, reviews, case reports, qualitative studies and congress reports were not included in the study.

Search Strategy

Publications in English between March 2003 and January 2022 were included in the study. A search was made between November 2020 and January 2022 using PubMed, Web of Science, Science Direct, Google Scholar search engines to access articles published in international journals, and to access national publications, a search was made using the YOK National Thesis Center and Google Scholar search engines. The search medical subject headings (MeSH) terms were diabetic foot knowledge, self-efficacy, behavior, and combinations of these words. In order to access additional studies, the reference lists of the studies were examined.

Study Selection

The identification and selection of studies for this systematic review and meta-analysis was made independently by the first and second researchers (BD, EYA), first by title, then by abstract and full text, based on the inclusion criteria. When there was a difference of opinion about any study, the two researchers had a discussion and reached an

agreement. The PRISMA flow diagram regarding the selection process of the studies is given in Figure 1.

Data Collection and Risk-of-bias Assessment

As a result of the literature review, the authors reached 66 638 studies and reviewed the titles and abstracts of these studies. In the first stage, the review articles were eliminated. The researches included in the study were determined by first selecting by the title, then the abstract and the full text, after the repeated studies were removed from the search. Finally, full text articles meeting the inclusion criteria were reviewed and the remaining 26 articles were included in the systematic review (Figure 1).

The data extraction tool developed by the researchers was used to acquire the research data. With this data extraction tool, data on the study design and purpose, year of study, sample size, participant characteristics, mean age, duration of study, and country of study were collected. This process was carried out independently by the first and the second researchers (EYA, BD) and was checked by the third researcher (AO). The methodological characteristics of the included studies are presented in Table 1.

The methodological quality of the articles included in the study was evaluated by the first and the second researchers and checked by the third researcher. The authors used risk migration assessment tool provided by the Cochrane Collaboration tool for assessing the risk of bias in randomized trials. This approach used a “high risk”, “uncertain risk” and “low risk” to judge the following: random method adopted, allocation hidden, blind method of implementer and participant, ending blindness, incomplete outcome data, selective reporting bias and other biases (Figure 2).

Quality Assessment Results of Studies

Grades of Recommendation, Assessment, Development and Evaluation (GRADE) approach is used to provide an overall assessment of evidence relating to our outcomes, evaluating within-study risk of bias, inconsistency, indirectness, imprecision, risk of publication bias and other factors. The GRADE assessment resulted in one of four levels of “quality”: high, moderate, low or very low, and these expressed our confidence in the estimate of effect.²¹

Data Synthesis

The results of the research included in this systematic review were synthesized through meta-analysis. In the analysis in a meta-analysis, studies are examined in terms of mean, standard deviation and sample size. “Diabetes Knowledge Scale”, “Self-Care Activities”, “Diabetes Self-Efficacy Scale” pre-test ve post-test results were used as main outcomes. Totally, 9 studies were included. Three

studies for knowledge, 5 studies for behavior, 8 studies for self-efficacy were included in the meta-analysis. The main purpose of this method is to calculate the differences between the averages of the control and experimental groups in randomized controlled studies. I^2 defines the rate of variation in study estimates in consequence of heterogeneity instead of the sampling error.²² The heterogeneity test ($I^2 < 0.40$: fixed effect model, $I^2 > 0.40$: random effect model) is performed by selecting the appropriate model. Pooled-overall effect size as standardized mean difference (SMD) are generated using MedCalc 17.7.7 software. All tests were performed as two-tailed tests, and a p value of less than .05 was considered statistically significant.

Results

Description of Included Trials

Results from the databases were: PubMed (15 881), National Thesis Centre YOK (163), Science Direct (31 088), Google Scholar (19 506). A total of 66 638 articles were identified. In the first stage, review articles were eliminated. The studies included in the research were selected first by title, then abstract and full text, after the duplicate studies were removed. After removing duplicate studies, 336 remained. Three hundred ten articles were removed based on the study design. Finally 26 articles were included in the systematic review. The PRISMA flow diagram regarding the selection process of the studies is given in Figure 1.

Three studies for knowledge, 5 studies for behavior, 8 studies for self-efficacy were included in the meta-analysis. The total sample size of the studies included in the analysis was 2535 (experiment: 1464 and control: 1071). The mean duration of education for knowledge was 5.2 months, the mean duration of education for self-efficacy was 4.5 months and the mean duration of education for behavior was 4.8 months. The baseline characteristics of all studies were recorded (Table 1).

The Figure 2 summarize the methodological quality assessment and present the risk of bias. According to the evaluation of the studies in terms of their methodological quality; all of the studies provided detailed information about random sequence generation and allocation concealment; 55.6% of the studies has include information about blinding participants and personnel; 66.7% of the studies have blinding of outcome assessment, all of the studies do not have incomplete outcome data, and have selecting reported which refers to low reporting bias.

Results of Meta-analysis and Forest Plot Diagrams

The results of the analysis results according to the control and experimental groups measured in order to determine

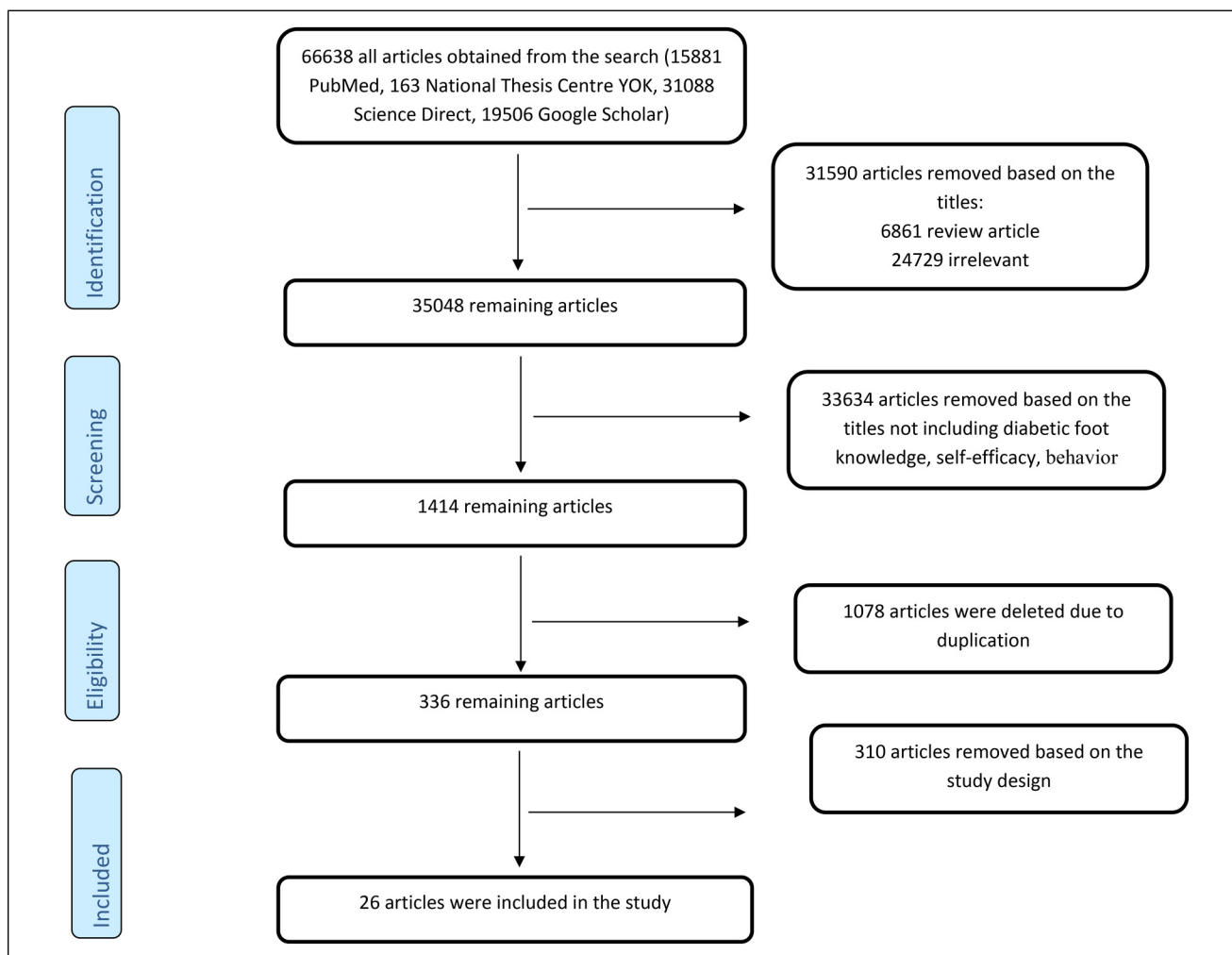


Figure 1. Systematic literature review (PRISMA FLOW DIAGRAM).

the effect of the knowledge levels of the studies, SMD are given in the Table 2. According to the groups; the highest mean difference between group is 2.399. There are heterogeneity between the knowledge levels of the studies. Accordingly, when the SMD of the studies included in meta-analysis are examined, there is significant difference in their knowledge levels. Forest plot diagram for knowledge levels shown in Figure 3.

The results of the analysis results according to the control and experimental groups measured in order to determine the effect of the behavior levels of the studies on the post-test, SMD are given in the Table 3. According to the groups; the highest mean difference between group is 2.483. There are heterogeneity between the behavior levels of the studies. Accordingly, when the SMD of the studies included in meta-analysis are examined, there is significant difference in their behavior levels. Forest plot diagram for behavior levels shown in Figure 4.

The results of the analysis according to the control and experimental groups measured in order to determine the effect of the self efficacy levels of the studies, SMD are given in the Table 4. According to the groups; the highest mean difference between group is 1.820. There are heterogeneity between self efficacy levels of the studies. Accordingly, when the SMD of the studies included in meta-analysis are examined, there is no significant difference in their self efficacy levels. Forest plot diagram for self efficacy levels shown in Figure 5.

Discussion

Twenty-six²³⁻⁴⁸ studies were included in this systematic review and 9 studies were included in this meta-analysis to synthesize randomized controlled trials examining the effect of foot care education on knowledge, self-efficacy and behavior in patients with diabetes, and while positive changes were found in the knowledge levels and behaviors of patients after the education, no significant changes were

Table 1. The Methodological Characteristics of the Included Studies.

Number	Author	Country	Year	Sample	Type of study	Data Collection/Model	Study		Results
							Duration	Aim of study	
1	Emine Kir Biçer	Turkey	2016	90 diabetic patients	Randomized controlled study	Self efficacy	6 months	The aim of this study was to evaluate validity of Diabetic Foot Care Self Efficacy Scale (DFCSES), Diabetes Foot Knowledge Scala (DFKS) and Diabetic Foot Behavior Scala (DFBS) in Turkish population and to determine the effect of patient education on their perception of self efficacy	The initial scores and the scores after first, third and sixth months of all the scalas were compared. The scores of the study group showed increment where as the scores of the control group were the same. There was a statistically significant difference between the follow-ups. When the mean of the scores of DFCSES were evaluated separately according to the presence of actual foot wound, history of foot wound or amputation, physical examination of the foot and risk status for diabetic foot, there was a significant difference in the study population but not in the control group.
2	Beiranvand et al.	Iran	2015	69 diabetic patients	Randomized controlled study	Form of the Summary of Diabetes Self-Care Activities	3 weeks	It is aimed to evaluate the effect of an educational intervention on knowledge, attitude and practice of foot care.	After the intervention a significant increase was observed in the mean scores of other knowledge, attitudes, and foot care practice of the intervention group compared to those of the control group.
3	Kang et al.	Taiwan	2010	Type 2 56 diabetic patients	Randomized controlled study	The knowledge and attitude toward the diabetes questionnaire (KAQ)	12 months	This study aimed to compare family partnership interventional care (FPIC) with conventional care (CC) across a number of outcome measures in patients with poorly controlled type 2 diabetes.	There were significant differences in the scores of family supportive behaviors and patients' knowledge of and attitudes toward diabetes between the groups.

(continued)

Table 1. (continued)

Number	Author	Country	Year	Sample	Type of study	Data Collection/Model	Study		Results
							Duration	Aim of study	
4	Marchand et al.	France	2018	109 diabetic patients with grade 2 or 3 Neuropathy	Randomized study	Patient Interpretation of Neuropathy Questionnaire, Foot Care Confidence Scale, Multidimensional Health Locus of Control Scale	6 months	The purpose of this study is to evaluate the effects of new education program understanding of the disease, self-efficacy, locus of control, and application of prevention behaviors for foot ulcer	Intervention arm group showed a significant change in score between baseline and after 6 months for understanding the disease and prevention behaviors. For the sample as a whole (n = 109), there was a significant improvement between baseline and after 6 months for two questionnaires: understanding of disease and declared prevention behaviors.
5	Meryem Kılıç	Turkey	2020	88 diabetic patients	Randomized controlled study	Patient Description Form, Diabetic Foot Information Form, Diabetic Foot Behavior Scale, Diabetic Foot Care Self Efficacy Scale m-DAKBAS Assessment Form	6 months	This study aims to develop the Mobile Diabetic Foot Personal Care System (m-DAKBAS) related to foot care for diabetic individuals and to evaluate the effectiveness of this mobile application on the knowledge, behavior and self-efficacy of diabetic individuals.	Assessments showed that there was a statistically significant difference between the experimental and control group in terms of DFIF mean score in favor of the experimental group. However, no differences were defined in terms of the DFBS and DFCSES scores. In comparison to the control group, the patients in the experimental group had significant improvements in foot cracks, and there was a significant increase in the correct shoe selection.
6	Rahaman et.al.	India	2020	127 diabetic patients	Randomized controlled study	Knowledge form (14 items), Practice form (5 items)	3 months	The aim of this study to assess the effectiveness of a foot care education module for diabetes developed by us.	The change in knowledge score was statistically significant at third visit compared to first in the intervention group but not in the control group. Practice score also improved significantly in the intervention group in the

(continued)

Table 1. (continued)

Number	Author	Country	Year	Sample	Type of study	Data Collection/Model	Study		Results
							Duration	Aim of study	
7	Saadet Can Çiçek	Turkey	2021	90 diabetic patients	Randomized controlled study	Participant characteristics form, Diabetic foot evaluation form;, Diabetic foot knowledge subscale: and Foot Care Behavior Scale	6 months	This study aims to determine the effect of foot care and follow-up on improving foot care in elderly people with diabetes.	second visit but not in the control group. DFKS and FCBS showed significantly greater increases in intervention group compared to controls for each measurement from the beginning of monitoring in elderly who were applied education and monitoring after foot examination. Significant difference in total foot examination score was determined between groups and in time while similar change was seen in both groups. The results of the study have shown that education and monitoring were effective on developing foot care in elderly with DM.
8	Sharoni et al.	Malaysia	2018	76 diabetic patients	Randomized controlled study	Foot self-care behavior scale, Foot care self-efficacy scale, Knowledge of foot care scale	12 weeks	This study aimed to evaluate the effectiveness of health education programs based on the self-efficacy theory on foot self-care behavior for older adults with diabetes.	Foot self-care behavior, foot care self-efficacy (efficacy expectation), foot care outcome expectation and knowledge of foot care improved in the intervention group compared to the control group.
9	Corbett	USA	2003	40 diabetic patients	Randomized controlled study	The Interaction Model of Client Health Behavior, The Foot Care Knowledge Questionnaire, The Foot Care Practices Questionnaire	3 months	The purpose of the study was to test the effectiveness of an educational intervention to improve patients' foot care knowledge, self-efficacy and self-care practice.	The educational intervention improved patients' knowledge, confidence, and reported foot care behaviors.
10		UK	2012		Randomized	Therapeutic model	10 weeks	This study is reviewed the	A randomized controlled

(continued)

Table 1. (continued)

Number	Author	Country	Year	Sample	Type of study	Data Collection/Model	Study Duration	Aim of study	Results
	Vedhara et.al.			13 diabetic patients	controlled study			existing evidence in this area and developed a therapeutic model which informed the content, structure and format of a psychosocial intervention designed to modify the psychosocial risk factors associated with reulceration.	clinical trial is required to establish the intervention's effectiveness in reducing the risk of further diabetic foot ulcers and improving ulcer management in the event of re-ulceration.
11	Ghoreishi et al.	Iran	2019	120 diabetic patients	Randomized controlled study	Social cognitive model, Diabetes self-care questionnaire,	3 months	This study aimed to determine the effect of education intervention, based on social cognitive theory, on self-care behaviors in patients with type 2 diabetes.	After the intervention, there was a significant difference in self-care, knowledge, outcome expectations, outcome value, self-efficacy, self-efficacy to overcome barriers, environment, observational learning, situational perception, self-regulation and emotional adaptation in the intervention group.
12	Borges et al.	USA	2008	167 diabetic patients	Randomized controlled study	Foot Self-Care Knowledge, Diabetes Self-Efficacy, Foot Self-Care Behaviors	1 month	The purpose of this experimental study was to determine whether a 15-min intervention, Pies Sanos, which was culturally and linguistically appropriate, would improve foot self-care knowledge and behaviors in adult patients with type 2 diabetes who presented for nonemergent care in two community hospital emergency departments (ED).	At follow-up, there was a significant difference in observed foot self-care behaviors between groups, as well as a significant difference within the intervention, and control group, for baseline and follow-up self-reported foot self-care behaviors. Baseline diabetes self-efficacy was significantly and positively correlated with both baseline and follow-up foot self-care behaviors.
13	Fan et al.	Canada	2013	56 diabetic patients	Randomized study	Foot Self-Care Knowledge,	3 months	This study aimed to explore the effects of an educational intervention on patients'	The findings indicated that the foot self-care educational intervention

(continued)

Table 1. (continued)

Number	Author	Country	Year	Sample	Type of study	Data Collection/Model	Study		Results
							Duration	Aim of study	
14	Atak et al.	Turkey	2008	80 type 2 diabetic patients	Randomized controlled study	Self-Efficacy, and Behaviors Self management behaviors were measured by knowledge test; self efficacy of patients was measured by mean scores of diabetes self efficacy scale	2 weeks	The aim of the study was to evaluate the effect of patient education on knowledge, self management behavior and self efficacy in patients with type 2 diabetes	Patient education had a limited effect on knowledge and self reported self management behaviors but a significant effect on self efficacy in patients with type 2 diabetes.
15	Guo et.al.	Taiwan	2014	28 diabetic patients	Randomized study	Questionnaires of diabetes self-care knowledge, behavior and efficacy	6 weeks	The research team developed a system, called Mobile Diabetes Self-Care System, for people with diabetes, which facilitates the patients to enhance their self-care ability and practices with the flexibility of timing, location and choices. The study evaluates the system's effectiveness in patients' self-care knowledge, behavior and efficacy.	The mobile system enhanced the patient's self-care knowledge and behavior by 17% and 22%, respectively, with statistical significance, yet only marginally increased their self-efficacy
16	Dunbar et.al.	USA	2014	71 diabetic patients	Randomized controlled study	DM knowledge, self-care efficacy, self-care behaviors, and quality of life (QOL).	3 months	This study tested an integrated self-care program for its effects on heart failure (HF) and DM knowledge, self-care efficacy, self-care behaviors, and quality of life (QOL). Hospitalized HF-DM participants (N = 71) were randomized.	The integrated HF-DM self-care intervention conferred effects on improved HF knowledge, HF self-care maintenance, HF self-care management, DM self-efficacy, general diet, HF physical QOL, and emotional QOL scores at 90 days within the intervention group. The participants in the usual care group also reported

(continued)

Table 1. (continued)

Number	Author	Country	Year	Sample	Type of study	Data Collection/Model	Study Duration	Aim of study	Results
17	Lee et al.	Korea	2019	60 diabetic patients	Randomized controlled study	Self-Efficacy, Self-Care Behaviors	6 months	This study investigated the effect of applying customized diabetes education program through pattern management (PM), using continuous glucose monitoring system (CGMS) results, on individual self-care behaviors and self-efficacy in patients with type 2 diabetes mellitus.	increased total and physical QOL Self-efficacy showed statistically significant interactions between the two groups over time, indicating a significant difference in the degree of self-efficacy between the PM education and control groups.
18	Wichit et al.	Australia	2016	Type 2 140 diabetic patients	Randomized controlled study	Diabetes Self-Care Activities Scale, Diabetes Management Self-Efficacy Scale, Diabetes Knowledge Questionnaire	13 weeks	In this study, it is evaluated a theoretically-derived family-oriented intervention aimed to improve self-efficacy, self-management, glycemic control and quality of life in individuals living with Type 2 diabetes.	Diabetes self-efficacy, self-management, and quality of life improved in the intervention arm but no improvement was observed in the controls. In the risk-adjusted multivariable models, compared to the controls, the intervention arm had significantly better self-efficacy, self-management, outcome expectations, and diabetes knowledge.
19	Jiang et al.	China	2019	Type 2265 diabetic patients	Randomized controlled study	Self-efficacy, self-management behaviors and knowledge	6 months	The aim of the study is to evaluate the effectiveness of a self-efficacy-focused structured education programme on outcomes in adults with type 2 diabetes (T2DM) without insulin therapy.	Self-efficacy, self-management behaviors and knowledge improved significantly in the intervention group compared with the control group at 6-month follow-up.
20	Wallace et al.	China	2009	230 diabetic patients	Randomized controlled study	Self-efficacy, engagement in care, and knowledge	3 months	In this pilot study, it is evaluated the impact of providing patients with a literacy-appropriate diabetes education guide accompanied by brief	Significant and clinically important improvements were observed in participants' activation, self-efficacy, diabetes-related distress, and self-reported behaviors, and

(continued)

Table 1. (continued)

Number	Author	Country	Year	Sample	Type of study	Data Collection/Model	Study		Results
							Duration	Aim of study	
21	Hailu et al.	Ethiopia	2019	142 Type 2 diabetic patients	Randomized controlled study	Diabetes Knowledge Scale, Self-Care Activities, Diabetes Self-Efficacy Scale	6 months	It is prepared a diabetes self-management education (DSME) intervention and assessed how it affected patients' self-reported levels of diabetes knowledge, self-care behaviors, and self-efficacy	knowledge. Improvements were similar across literacy levels. The difference in the mean Diabetes Knowledge Scale scores before and after the DSME intervention was significantly greater in the intervention group. There were no significant differences within or between the groups in other self-reported diabetes self-care behavior regimens or in diabetes self-efficacy.
22	Peimani et al.	Iran	2017	200 diabetic patients	Randomized controlled study	Self-care behaviors, self-efficacy and life quality	6 months	This study aims to assess the effectiveness of a peer support intervention, in which patients with T2DM were provided ongoing self-management support by trained peers with diabetes directed at improving self-care behaviors, self-efficacy and life quality.	Mean diabetes self-management scores, mean self-efficacy scores and mean quality of life scores significantly improved in peer support group compared to control group.
23	Wishah et al.	Jordan	2015	106 diabetic patients	Randomized controlled study	Knowledge about diabetes, patients' adherence to prescribed medications and diabetes self-care activities	6 months	The primary aim of this study was to evaluate the impact of pharmaceutical care interventions on glycemic control and other health-related clinical outcomes in patients with type 2 diabetes patients in Jordan.	The mean scores of patients' knowledge about medications, knowledge about diabetes and adherence to medications and diabetes self-care activities of the patients in the intervention group increased significantly compared to the control group.
24	Hermanns et al.	Germany	2013	160 diabetic patients	Randomized	Self-Care Activities Scale, Diabetes	6 months	Primary outcome was the effect on glycaemic control	Incidence of severe hypoglycemia, hypoglycemia

(continued)

Table 1. (continued)

Number	Author	Country	Year	Sample	Type of study	Data Collection/Model	Study Duration	Aim of study	Results
25	Azami et al.	Malaysia	2018	Type 2 142 diabetic patients	controlled study	Self-efficacy Scale, Self-report scale	5 weeks	in a 6-month follow-up. Secondary outcomes were the impact on emotional aspects, self-management related aspects and hypoglycaemia problems. The aim of this study was to investigate the effectiveness of a nurse-led diabetes self-management education on glycosylated hemoglobin.	awareness, diabetes knowledge, and self-care behavior improved in both groups with no significant differences between groups. Patients in the intervention group showed significant improvement in, efficacy expectation, outcome expectation, and diabetes self-management behaviors.
26	Dincer et al	Turkey	2021	Type 2 130 diabetic patients	Randomized controlled study	Diabetic Foot Care Self Efficacy Scale (DFCSES), Diabetes Foot Knowledge Scala (DFKS) and Diabetic Foot Behavior Scala (DFBS)	1 month	The aim of the study is to develop an animation-supported Mobile Diabetic Foot Care Education (M-DFCE) application and increase knowledge, behavior and attitude levels.	Although there was no difference between the groups at initial evaluation, individuals in the experimental group who received animation-supported M-DFCE had significantly higher knowledge, self-efficacy and foot care behavior levels than control group.

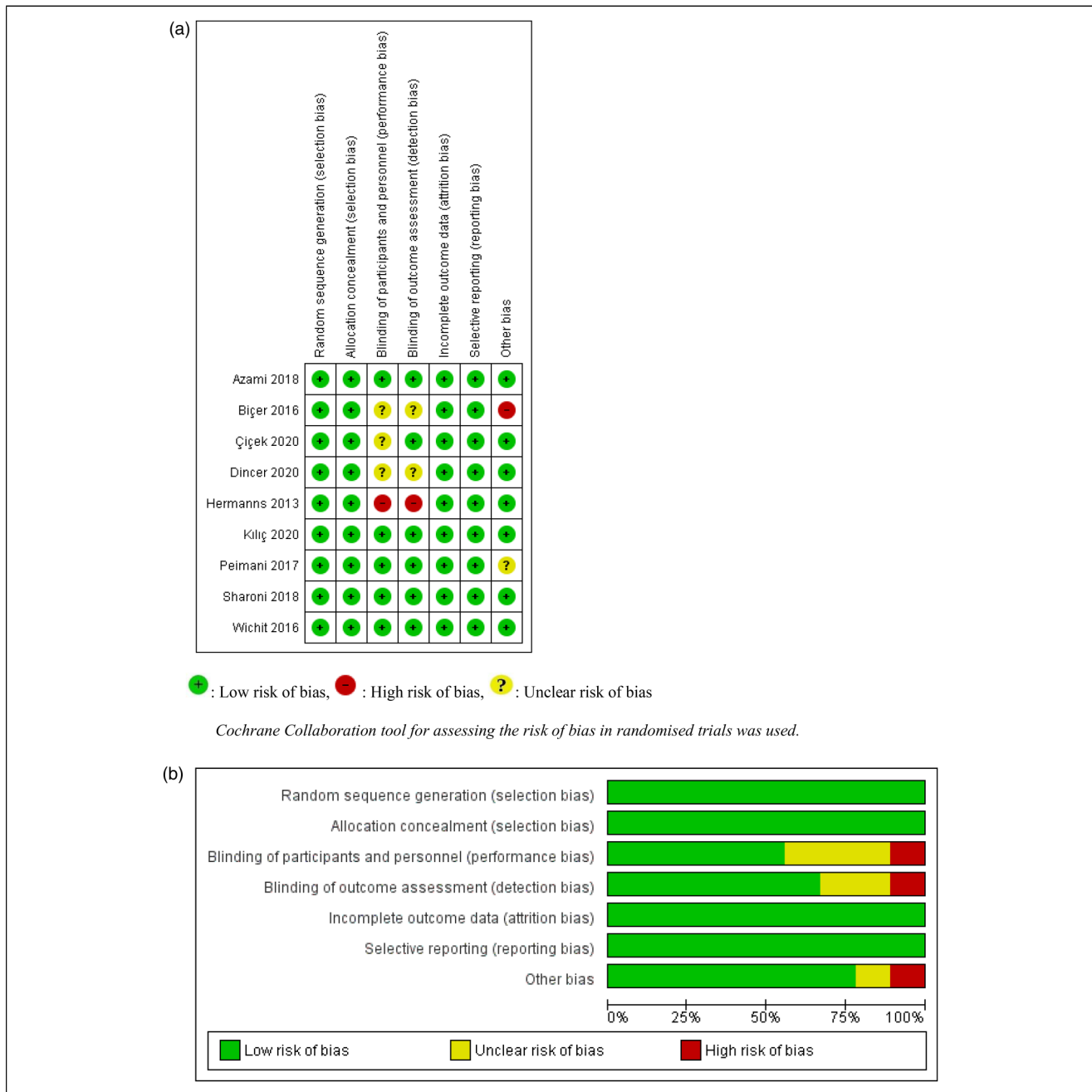


Figure 2. Quality of assessment.

observed in self-efficacy. There are studies in the literature on diabetic foot management and education but no evidence-based studies, in which knowledge, self-efficacy, and behavior regarding diabetic foot care were examined together, to the best of our knowledge. Considering the importance of preventing diabetic foot wounds and complications related to foot wounds through education, the present study is believed to contribute to the literature regarding the trainings to be provided.

Meta-analysis revealed that the level of heterogeneity was high. When heterogeneity is high, it is recommended that for variables such as population, intervention, results and measurement methods that may affect study results be analyzed precisely.⁴⁹ In our study, the population consisted of patients with diabetes. Training was conducted as an intervention, and thus, patients' levels of knowledge, self-efficacy, and behaviors were evaluated. However, the education materials, styles, duration and frequencies of studies included, were

different. While Ahmad Sharoni et al used Power Point presentation and a pamphlet at least 30 min in their study,⁵⁰ Cicek and Gokdogan conducted face-to-face trainings that lasted at least 2 h,⁴¹ whereas Kilic and Karadağ provided training to patients through a mobile application that was available for a maximum of 6 months,³⁹ Dincer and Bahçecik provide same method only one month.⁴⁸ High heterogeneity may be due to the fact that a standard educational intervention was not implemented. In the studies, diabetic foot training was conducted in different ways, such as through individual and/or group sessions and face-to-face training, and telemedicine. Considering that all these methods can be easily implemented in daily practice, and the diabetic foot and its complications lead to an increased risk of amputation,⁵¹ deterioration in QOL⁵² and high health care costs,⁵³ the significance of diabetic foot education will be better understood. In this meta-analysis, in which studies conducted between March 2003 and January

2022 are included, unlike previous meta-analyzes, current studies, in which developing health technologies were used, were also included. Although this led to the heterogeneity of the effect sizes of the results, the results that led to significant positive changes were obtained, and it was shown that telemedicine-based education, which was easier to implement, supported the positive results.

Examining the included studies,^{23,32,37,39,41,42,45,46,48} low risk of bias was found in four^{32,39,42,45} of the randomized controlled trials in which information, self-efficacy and behavior of patients were examined. In addition to these, there were studies with a low risk of bias aimed only at increasing the level of knowledge⁴² and self-efficacy.⁴⁵ In a systematic review by Goodall et al including 13 randomized controlled trials, it was stated that the studies were of insufficient quality to conclude that the diabetic foot education provided to patients had a positive effect on behavior and self-efficacy.⁵⁴ In evidence-based studies,

Table 2. The Impact of Foot Care Education on Knowledge Levels.

No	Study	N (Study)	N (Control)	SMD	SE	95% CI
1	Biçer (2016)	45	45	1.240	0.229	0.786 to 1.694
7	Çiçek (2021)	45	45	2.399	0.275	1.852 to 2.946
26	Dincer (2021)	65	65	1.393	0.195	1.008 to 1.778
	Total (random effects)	155	155	1.656	0.326	1.014 to 2.299

Heterogeneity: $I^2 = 83.33\%$, $P = .003 < .05$, Grade quality of data: moderate.

The GRADE quality of evidence was downgraded one level due to imprecision. There is no explanation about the blinding procedure.

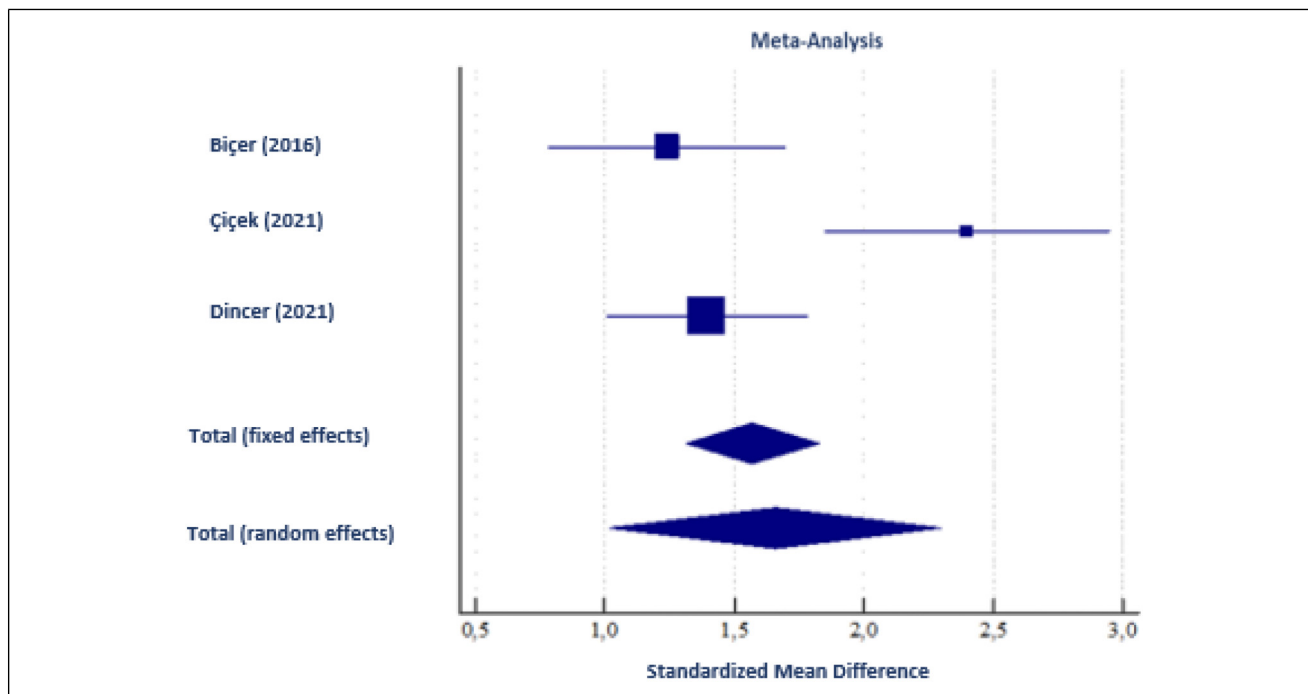


Figure 3. Forest plot diagram for knowledge levels.

Table 3. The Impact of Foot Care Education on Behavior Levels.

No	Study	N (Study)	N (Control)	SMD	SE	95% CI
1	Bıçer (2016)	45	45	0.831	0.218	0.398 to 1.265
5	Kılıç (2020)	44	44	0.337	0.213	-0.0866 to 0.760
7	Çiçek (2021)	45	45	2.483	0.279	1.928 to 3.038
8	Sharoni (2018)	38	38	2.009	0.279	1.452 to 2.566
26	Dincer (2021)	65	65	0.702	0.180	0.346 to 1.057
	Total (random effects)	237	237	1.045	0.100	0.849 to 1.242

Heterogeneity: $I^2 = 99.61\%$, $P < .001$. Grade quality of data: moderate.

The GRADE quality of evidence was downgraded one level due to imprecision. There is no explanation about the blinding procedure.

the importance of using valid, reliable and useful scales for the measurement method is emphasized.⁵⁵ In our study, valid and reliable measurement tools (Diabetes Knowledge Scale, Self-Care Activities, Diabetes Self-Efficacy Scale) were used to measure information, self-efficacy, and behavior. The studies included in the analysis had adequate methodological explanations and adequately addressed the risk of bias. Our study has strong features with these aspects. However, the number of double blind randomized trials in terms of both participants and those providing education is very few.^{32,39,42,45} It may be difficult to implement the double-blind method in randomized controlled trials.⁵⁶ Furthermore, 4 studies did not use the CONSORT checklist.^{23,32,39,41} The results of the meta-analysis show that future studies should be designed to minimize the risk of bias. We are of the opinion that suitable randomization and reporting using the CONSORT checklist will help minimize the risk of bias.⁵⁶

In the present study, it was determined that diabetic foot education positively affected the knowledge and behavior of patients. A systematic review evaluating patients with diabetes noted that the 5-year mortality rate of patients was 40-90% after amputation, and most of these complications were preventable by a comprehensive annual foot examination and routine foot care performed by patient.⁵⁷ Several studies reported that foot amputations would be greatly reduced with good patient education, awareness and education of healthcare professionals.^{16,17} A systematic review evaluating the implementation of health education programs for elderly patients with diabetes demonstrated that there was improvement in diabetic foot self-care of patients and decrease in foot problems such as neuropathy, ulcer, tinea pedis, callus grade and foot disability.⁵⁰ A meta-analysis by Norris et al found that individuals who received diabetic foot education had better self-care skills and higher level of knowledge about diabetes.⁵⁸ In a meta-analysis involving randomized controlled trials evaluating the effect of diabetic foot education on foot ulcers, 5 out of 8 studies reported improvement in knowledge about diabetic foot, and 7 out of 9 studies reported improvement in self-care behavior.⁵⁹ In this meta-analysis, the incidence of foot ulcers was

evaluated in 5 studies, and education reduced the incidence of foot ulcers in only one study.⁵⁹ These results show that diabetic foot education improves the knowledge and behavior of patients in the short term, although it might be insufficient on clinical outcomes. Many factors affecting diabetes control such as lifestyle change and drug treatments, psycho-social evaluations, diabetes self-management education (DSME), close follow-up of patients, clinical inertia are effective in this regard. Diabetes is a disease that requires a multidisciplinary approach, and diabetic foot education is one of the most important parts of this teamwork. European Society for Vascular Surgery guidelines state that diabetic foot education conducted “in a structured and organized manner” as part of the multidisciplinary management of patients with diabetes, plays an important preventive role.⁶⁰ Diabetes care programs involving doctors, nurses for diabetes education, dietitians and medical social service specialist will improve clinical outcomes.⁶¹

It is noteworthy that after the diabetic foot education, there was improvement in the knowledge and behavior of the patients, with no significant change in self-efficacy. In chronic diseases, it is critical for the patient to adopt self-care behaviors as a lifestyle.^{62,63} Diabetic foot care and taking preventive measures are skills that the patients should maintain throughout their lives. It is promising that knowledge and behavior improve in the short term after education, but it is inevitable that this effect will last short unless the attitude changes. Unfortunately, attitude is the one that changes last and the most difficult to change. Some studies in the literature state that increasing or improving the perception of self-efficacy will not take place all of a sudden and that it may take time.^{64,65} In the study of Gökdeniz and Akgün Şahin, it was shown that the level of diabetic foot knowledge is higher in those who have diabetes for 21 years or more, and that their self-care is better in those who go to the doctor every month.⁶⁶ In studies conducted, the results of patients in the short term were evaluated. We are of the opinion that self-efficacy will improve when education is provided regularly at certain intervals. There is a need for longitudinal studies in which changes in knowledge, self-efficacy and behavior

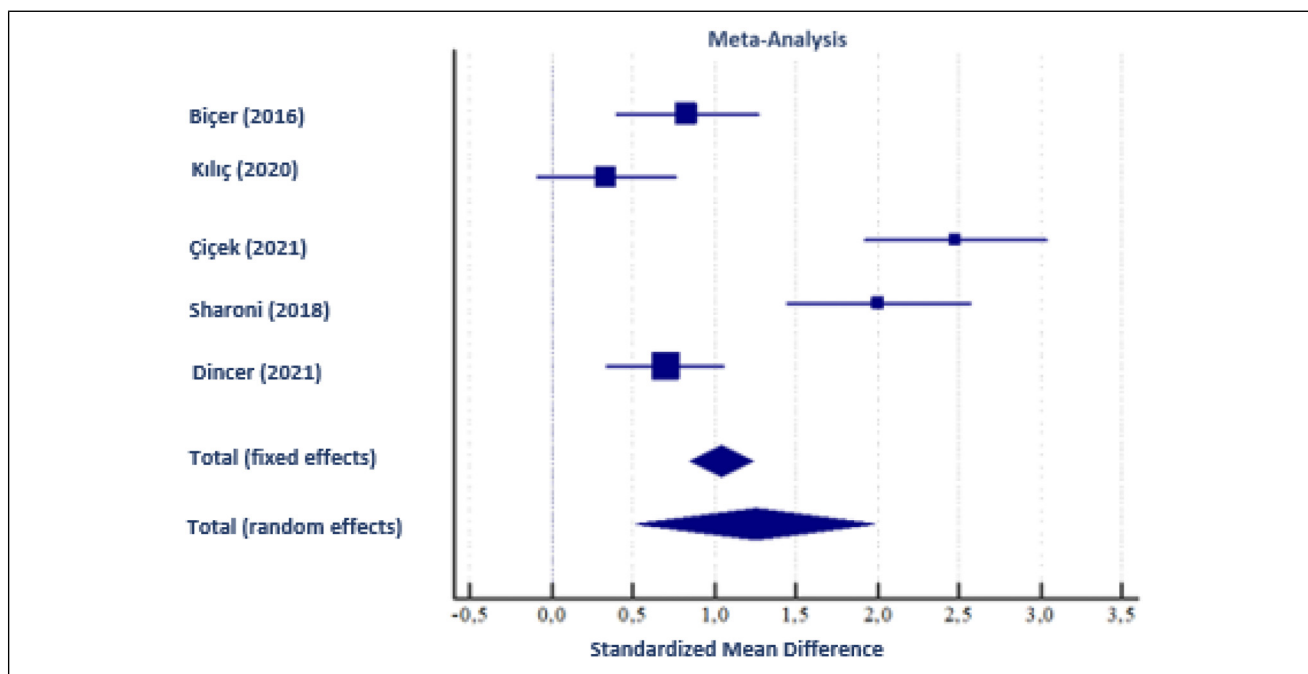


Figure 4. Forest plot diagram for behavior levels.

Table 4. The Impact of Foot Care Education on Self-efficacy Levels.

No	Study	N (Study)	N (Control)	SMD	SE	95% CI
1	Biçer (2016)	45	45	0.865	0.219	0.431 to 1.300
5	Kılıç (2020)	44	44	0.217	0.212	-0.205 to 0.638
8	Sharoni (2018)	38	38	1.184	0.247	0.693 to 1.675
18	Wichit (2016)	70	70	1.335	0.186	0.967 to 1.703
22	Peimani (2017)	78	64	0.945	0.177	0.595 to 1.295
24	Hermanss (2013)	100	100	-2.541	0.190	-2.915 to -2.167
25	Azami (2018)	71	71	1.820	0.199	1.427 to 2.213
26	Dincer (2021)	65	65	0.644	0.179	0.290 to 0.998
	Total (random effects)	511	497	0.557	0.489	-0.402 to 1.517

Heterogeneity: $I^2 = 97.94\%$, $P < .001$, Grade quality of data: moderate.

The GRADE quality of evidence was downgraded one level due to imprecision. There is no explanation about the blinding procedure.

are observed after patients are provided with intermittent educations lasting longer than 1 year.

If a patient has enough knowledge, they can reflect this in their behavior and adopt it as a lifestyle. Perrin et al found a positive relationship between the knowledge and attitudes of patients with diabetes and their diabetic foot care behavior scores.⁶⁷ Also, they observed a positive correlation between self-efficacy beliefs and preventive behaviors of patients.⁶⁷ Educations provided concerning cognitive, affective and psycho-motor domains should complement each other. Knowledge, self-efficacy and behavior are an inseparable whole and are affected by many external factors. Diabetic foot education should also be supported by psychosocial

support and motivational work. The IWGDF guidelines recommend “training aimed at improving foot care knowledge and behavior, as well as encouraging the patient to follow the given foot care advice” for the prevention of foot ulcers in diabetic patients at risk.¹⁰ In a meta-analysis, it was found that motivational interviews for the prevention of diabetic foot ulcers were effective in terms of positive behavioral changes.⁶⁸ Patients with diabetic foot fear lower extremity amputation more than death.^{69,70} It has been shown that the education given to patients with type 2 diabetes improves the psychological state of the patients as well as their blood glucose levels.⁷¹ There is a need for comprehensive studies evaluating the associated factors in this field.

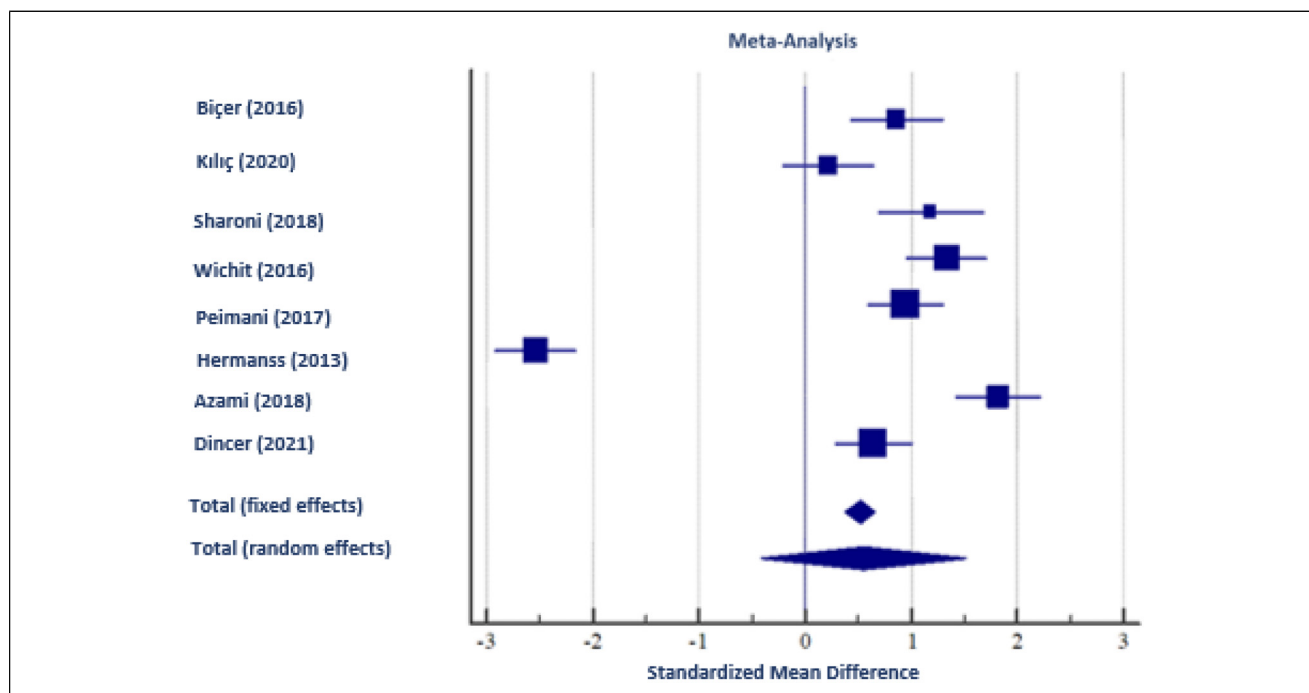


Figure 5. Forest plot diagram for self-efficacy levels.

Diabetic foot education is an issue that needs to be continuously improved through studies and patient feedback. A patient-centered approach can improve results by identifying issues that should be primarily focused on.⁷² In a study, in which diabetic foot education was given in stages, first, patients' awareness was evaluated, and their awareness was raised through education. At the end of the study, it was found that the learning gain of patients was 76.5%.⁷³ All these results show that the correct implementation of diabetic foot education leads to strikingly positive results. According to the results of this systematic review and meta-analysis, we believe that multidisciplinary diabetic foot education concerning cognitive, affective and psychomotor domains will improve the knowledge, self-efficacy and behavior of patients.

Limitations

Our study had some limitations. The first is that only studies published in English are included. Studies published in other languages are not included due to language restrictions. Second, the results of the study cannot be generalized to people with diabetes around the world. Although data from different continents and countries were compiled, data from many countries with significant populations were not taken. Third, full texts of some studies could not be accessed during the literature review. In such cases, the authors were tried to be reached via email, but they responded late or never responded. Fourth is the lack of

methodological explanations and missing data in some studies. Fifth, many studies, in which diabetes education did not focus on foot care or which did not examine knowledge, self-efficacy, and behavior were excluded. This means that several studies with potentially relevant results (though significantly confusing) were excluded from the analysis. This decision was taken so that the results of this systematic review were directly related to the provision of foot care education. Sixth, unpublished and ongoing studies were not included in the study. Furthermore, despite rigorous adherence with appropriate systematic review methodology, it is possible that studies were missed by the search and thus inappropriately excluded from the analysis.

Conclusion

In this study, the effect of education on diabetic foot care for patients with diabetes was evaluated with a systematic review and meta-analysis, and solid evidence was obtained. The results of a systematic review of twenty-six studies and a meta-analysis of 9 studies showed that diabetic foot education improved the level of knowledge and behavior of patients with diabetes, while not affecting their self-efficacy. It is expected that patients, healthcare professionals, companions of patients, academics and the whole society will benefit from the study results. Doctors and nurses playing an important role in diabetes management are expected to increase the quality of care with a cost-effective educational intervention which is easy to conduct. It is thought that

patients and their companions will gain knowledge and awareness about the effect of diabetic foot care education. It is believed that the study will contribute to academics' knowledge of the effectiveness of patient education in diabetic foot management and the meta-analysis method, and give some ideas for planning different meta-analyses. Additionally, the results of the study will contribute to the literature. It is recommended that the number of nationwide and international randomized controlled trials investigating the impact of diabetic foot education focused on improving the knowledge, self-efficacy and behavior levels of patients with diabetes be increased. The results are a guide for future researchers and will provide appropriate planning for research designs.

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Declaration of Conflicting Interests

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Ethical Approval

Not applicable, because this article does not contain any studies with human or animal subjects.

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