



Effect of Animaker and Augmented Reality on knowledge, Attitude, and Behavior toward Non-Ulcer Foot Care in Patients with Type 2 Diabetes



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ABSTRACT

Aims Diabetic ulcers are chronic, open wounds that penetrate through the skin's outer layer into the deeper dermal tissue. This research aimed to discover how augmented reality media and Animaker affect non-ulcer foot care behavior among people with type 2 diabetes, specifically regarding foot care education.

Materials & Methods This quasi-experimental study employed a pre-test-post-test design with a control group and was conducted on 44 participants. The subjects were divided into three groups, including the intervention group (augmented reality+Animaker), positive control group 1 (augmented reality), and positive control group 2 (Animaker). Data were collected using observation sheets and questionnaires, and analyzed by the Wilcoxon signed-rank and Kruskal-Wallis tests at a significance level of ≤ 0.05 .

Findings The post-test knowledge, attitude, and behavior scores increased in the intervention group, positive control group 1, and positive control group 2. Also, disparities were found in the effectiveness of enhancing knowledge ($p=0.047$), attitudes ($p=0.022$), and behavior ($p=0.037$) among the combined media of augmented reality+Animaker, augmented reality, and Animaker.

Conclusion The use of AR media, Animaker, or a combination of both increases knowledge, attitudes, and behavior toward treating diabetic foot ulcers.

Keywords Diabetes Mellitus; Augmented Reality; Diabetic Ulcer; Foot

CITATION LINKS

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Introduction

Diabetic ulcers are chronic, open wounds that penetrate through the skin's outer layer into the deeper dermal tissue, predominantly affecting individuals with diabetes mellitus (DM). These ulcers represent a significant health concern due to their complexity and the extensive resources required for treatment [1]. Managing diabetic ulcers involves considerable financial and time investments, and these complications are among the most feared by patients with DM because of their potential to lead to severe outcomes such as amputation [2,3]. Amputation not only exacerbates physical disabilities but also profoundly impacts a patient's quality of life, leading to increased psychological distress and reduced functional independence [3].

Globally, diabetes is a burgeoning epidemic, with the International Diabetes Federation (IDF) estimating that over 371 million individuals will be affected by diabetes by 2023 [4]. In Indonesia, the prevalence of DM has risen from 1.1% in 2021 to 2.1% in 2022, underscoring a growing public health challenge [5]. This increase in prevalence highlights the importance of addressing risk factors associated with diabetic ulcers, such as vascular disease, neuropathy, and other diabetes-related complications.

Several factors contribute to the development of diabetic ulcers. Risk factors include the presence of foot deformities, calluses, visual impairments, age-related changes, and poor glycemic control. Additionally, individuals with a history of foot wounds or decreased sensation in the feet are particularly vulnerable [6]. Hyperglycemia, a hallmark of diabetes, leads to neuropathy and diminished sensation, which impairs the ability to detect injuries and results in altered pressure distribution on the feet, facilitating ulcer formation [7, 8]. The compromised immune response associated with hyperglycemia also increases susceptibility to infections, potentially leading to severe complications, such as gangrene if not managed appropriately [9, 10].

Preventing and managing diabetic ulcers requires a multifaceted approach, including regular assessment of vascular and circulatory health, stringent glucose control, and patient education on foot care [11]. Effective foot care aims to minimize the risk of complications and potential amputations by encouraging proactive management and regular monitoring of foot health [12]. Educational interventions play a crucial role in empowering patients to take charge of their foot health, thereby reducing the incidence of foot complications and improving overall outcomes [13].

Recent advances in technology offer innovative solutions for enhancing patient education. Augmented reality (AR) has emerged as a promising tool in this domain, demonstrating increased patient satisfaction and knowledge retention compared to

traditional methods [14-16]. For instance, AR applications, like Animaker use interactive graphics and sound to convey essential foot care information, providing a more engaging and effective learning experience than conventional text-based materials. By integrating AR technology into educational programs, we can potentially improve patient outcomes by fostering a better understanding and adherence to foot care practices.

This study aimed to explore the impact of AR media, specifically an Animaker video, on non-ulcer foot care behaviors among individuals with type 2 diabetes mellitus (T2DM). By comparing AR-based educational interventions with traditional methods, we aimed to determine the effectiveness of AR in enhancing foot care practices and reducing the risk of diabetic ulcers.

Materials and Methods

Design

This quasi-experimental study employed a pre-test-post-test design with a control group and was conducted in Banjarmasin City from January through June 2023.

Inclusion and exclusion criteria

Inclusion criteria were patients aged 18 and older with a confirmed diagnosis of T2DM, willingness to provide informed consent to participate in the study, ability to understand and engage with educational materials, access to smartphones, tablets, or computers to engage with Animaker and AR interventions, and no previous formal education on non-ulcer foot care within the past year. Exclusion criteria included patients with acute diabetic complications (e.g., diabetic ketoacidosis and severe infections) that may interfere with participation, patients with cognitive impairments or conditions affecting their ability to engage with educational content, individuals with serious comorbidities, patients who have participated in similar educational programs within the last year, and patients who do not speak the language of the educational materials and cannot communicate effectively with researchers.

Sample size and groups

To account for potential dropouts, the sample size was increased by 10% for each group based on the Lameshow formula, resulting in a total sample size of 44 respondents for each group, including the intervention group (AR+Animaker), positive control group 1 (AR), and positive control group 2 (Animaker). Purposive sampling was used to select the respondents for each group. No respondents withdrew from the study.

Intervention

The intervention involved providing animation-based videos and patterned images that support AR; the AR images were displayed using an Android camera, which then made the AR images appear to

move and come to life. The intervention was carried out for 7-10 minutes a day, three times a week for three months.

Data collection

The tools used included an action observation sheet adapted from the Patient Interpretation of Neuropathy (PIN) Questionnaire, and a questionnaire on demographic information, knowledge, and attitudes regarding neuropathy.

Data analysis

The collected data were analyzed by SPSS 29 using the Wilcoxon signed-rank and Kruskal-Wallis tests at a significance level of $p \leq 0.05$.

Findings

The three age groups were homogenous as the majority of respondents were middle-aged (45-59 years old), predominantly female, and had a senior high school education (Table 1).

Table 1. Frequency of participants' demographic characteristics (n=132)

Characteristics	Intervention group	Positive control group 1	Positive control group 2
Age (year)			
Adult (31-44)	8(18.18)	4(9.09)	6(13.64)
Middle-aged (45-59)	34(77.27)	39(88.64)	37(84.09)
Elderly (60-74)	2(4.55)	1(2.27)	1(2.27)
Gender			
Male	20(45.45)	16(36.36)	17(38.64)
Female	24(54.55)	28(63.64)	29(65.91)
Education			
Elementary school	9(20.45)	10(22.73)	7(15.91)
Junior high school	10(22.73)	12(27.27)	14(31.82)
Senior high school	17(38.64)	16(36.36)	17(38.64)
Academic	8(18.18)	6(13.64)	6(13.64)

The post-test knowledge scores increased in the intervention group (from 20.45% to 61.36%), positive control group 1 (from 18.18% to 52.27%), and positive control group 2 (from 25% to 56.82%).

Meanwhile, the post-test attitude scores increased significantly in the intervention group (from 31.82% to 72.73%), positive control group 1 (from 45.45% to 65.91%), and positive control group 2 (from 36.36% to 70.45%). Also, the post-test behavior scores were assessed as good in all three groups and increased in the intervention group (from 27.27% to 61.36%), positive control group 1 (from 15.91% to 54.55%), and positive control group 2 (from 22.73% to 59.09%; Table 2).

According to the Wilcoxon signed-rank test, foot care education using the combined media of AR+Animaker ($p=0.005$) and AR ($p=0.011$) had an impact on patients' knowledge of non-ulcer foot care in individuals with T2DM; however, no discernible impact of Animaker media education was observed ($p=0.097$). In addition, the Kruskal-Wallis test showed a significant difference in knowledge among the three groups after receiving non-ulcer foot care education through the AR+Animaker, AR, and Animaker in T2DM sufferers ($p=0.047$).

On the other hand, the Wilcoxon signed-rank test revealed that the attitudes of type 2 diabetic patients toward non-ulcer foot care were influenced by the foot care education provided through the combined media of AR+Animaker, AR, and Animaker ($p=0.005$). Also, according to the Kruskal-Wallis test, there was a significant difference in attitudes among the three groups after receiving non-ulcer foot care education through the AR+Animaker, AR, and Animaker ($p=0.022$).

According to the Wilcoxon signed-rank test, foot care education significantly affected behavior in all groups. Also, according to the Kruskal-Wallis test, a significant difference was found in behavior among the three groups following non-ulcer foot care education through the AR+Animaker, AR, and Animaker ($p=0.037$; Table 3).

Table 2. Frequency of the knowledge, attitude, and behavior pre- and post-test scores

Parameter	Intervention group		Positive control group 1		Positive control group 2	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Knowledge						
Good	9(20.45)	27(61.36)	8(18.18)	23(52.27)	11(25.00)	25(56.82)
Enough	23(52.27)	11(25.00)	20(45.45)	14(31.82)	20(45.45)	16(36.36)
Poor	12(27.27)	6(13.64)	16(36.36)	7(15.91)	13(29.55)	3(6.82)
Attitude						
Positive	14(31.82)	32(72.73)	20(45.45)	29(65.91)	16(36.36)	31(70.45)
Negative	30(68.18)	12(27.27)	24(54.55)	15(34.09)	28(63.64)	13(29.55)
Behavior						
Good	12(27.27)	27(61.36)	7(15.91)	24(54.55)	10(22.73)	26(59.09)
Enough	18(40.91)	9(20.45)	21(47.73)	13(29.55)	19(43.18)	10(22.73)
Poor	14(31.82)	8(18.18)	16(36.36)	7(15.91)	15(34.09)	8(18.18)

Table 3. Bivariate test of measurement pre- and post-test

Parameter	Group	Wilcoxon signed ranks test	Kruskal Wallis test	
			Pre-test	Post-test
Knowledge	Intervention group	0.005		
	Positive control group 1	0.011	0.847	0.047
	Positive control group 2	0.097		
Attitude	Intervention group	0.005		
	Positive control group 1	0.005	0.858	0.022
	Positive control group 2	0.005		
Behavior	Intervention group	0.005		
	Positive control group 1	0.006	0.749	0.037
	Positive control group 2	0.011		

Discussion

This research aimed to discover how augmented reality media and Animaker affect non-ulcer foot care behavior among people with type 2 diabetes, specifically regarding foot care education. The results indicated that the level of knowledge about non-ulcer foot care in the positive control group 2 at the beginning of the measurement was predominantly in the poor category; however, after receiving education through Animaker media, most participants moved to the good category. The results of the Wilcoxon signed-rank test showed no significant difference between knowledge levels before and after education through Animaker media. In positive control group 1, the level of knowledge about non-ulcer foot care before receiving education through AR media was primarily in the poor category; after the education, most participants were in the good category. Similarly, the level of knowledge about non-ulcer foot care in the treatment group before receiving education through AR+Animaker media was mostly in the poor category, whereas after the education, almost all participants were in the good category. The results of the Wilcoxon test for knowledge in the positive control group 1 and the treatment group showed that there was a significant difference between knowledge before and after the intervention. Prior to receiving education through AR+Animaker media, the majority of the treatment group's knowledge regarding non-ulcer foot care fell into the poor category; however, following education through AR+Animaker media, nearly all of them moved into the good category. The knowledge obtained from the Wilcoxon test in both the treatment group and the positive control group 1 demonstrated a significant difference between their pre- and post-intervention knowledge.

When used in conjunction with audio-visual materials, Animaker media can raise the knowledge scores of individuals with T2DM regarding non-ulcer foot care [17]. The application of AR improved patient satisfaction and knowledge retention. Additionally, video media enhances the understanding of women of childbearing age about early cervical cancer detection in various circumstances [18]. One of the key factors in determining how someone acts is their knowledge. Knowledge is gained after an individual perceives a specific object. The goal of the learning process is to equip patients with knowledge so that cognitive control (which is ultimately responsible for the brain's learning and adaptation mechanisms) can be altered in relation to information processing, decision-making, and emotions [19]. Various factors, including media, education, social culture and economics, environment, experience, age, and others, all impact an individual's level of knowledge. Fifty percent of what we learn will stick in our memory if we hear and see it, compared to only 10% if we read it. The utilization of multiple health education media

types can enhance the quality of learning outcomes [20].

When individuals receive education through media or other tools, they become aware of stimuli, which piques their curiosity to observe and learn from the material in the educational media [21]. Animaker, a type of educational media, is limited to text and only stimulates one sense (the sense of sight), whereas video and AR media can simultaneously stimulate two senses (the senses of hearing and sight), making it easier to retain information—about half of what is learned [22]. Due to the respondents' interest in and awareness of non-ulcer foot care as a means of preventing diabetic ulcers, there was a change in knowledge across all three groups. It is easier for respondents to understand the information provided, and their interest and awareness increase when education is delivered through video/AR media [23], which contains moving images illustrating foot care steps, compared to Animaker, which consists of written content about foot care steps and is presented to respondents three times directly. Respondents were also provided with video/AR on CDs, which had a significant impact and allowed for independent study in addition to face-to-face instruction.

As a result of respondents' distaste for the Animaker media, which featured articles detailing steps for taking care of their feet along with multiple images, the change in their knowledge of non-ulcer foot care was less pronounced in the positive control group 2. This may be due to the aging demographic of the respondents, which makes it challenging for them to comprehend information presented solely through visual stimulation (a few pictures and some writing) [24]. All other factors were equal, most only completed high school. The knowledge shift among the respondents was greater when compared with the benefits of foot care education provided by the AR+Animaker combination media.

Prior to receiving education through Animaker media, the non-ulcer foot care attitude of positive control group 2 was primarily in the negative attitude category. However, following education through Animaker media, the non-ulcer foot care attitude shifted to half being in the positive attitude category. Before receiving education through AR media, half of the positive control group 1's attitude toward caring for non-ulcer feet fell into the negative attitude category. However, following education through AR media, the majority of the group's attitude toward caring for non-ulcer feet shifted to the positive attitude category. The intervention group's non-ulcer foot care attitude was primarily in the positive attitude category prior to receiving education through AR+Animaker media. However, following education through AR+Animaker media, the non-ulcer foot care attitude nearly completely transitioned to the positive attitude category. After

receiving the educational intervention on foot care, the attitudes of the three groups differed significantly, as indicated by the results of the Wilcoxon test.

Animaker media is effective in improving attitudes toward self-medication in accordance with the rules, while research by Animaker media researchers is effective in enhancing attitudes regarding non-ulcer foot care in people with T2DM. A person's attitude is constructed from three basic components: cognitive, affective, and conative [25].

The cognitive component represents trust and confidence in a particular object. The affective component reflects feelings and subjective emotional conditions toward certain objects. This emotional response can lead a person to maintain their attitude, even if that attitude is not necessarily positive. Meanwhile, the conative component refers more to the tendency of a person's actions and behaviors toward an object [25].

This framework provides an overview and reasons why some respondents have negative attitudes while others have positive attitudes [26]. Family support or the influence of other individuals who are considered important also strengthens changes in the sufferer's attitude [27].

An attitude is a conditioned response to a stimulus that considers relevant attention, feelings, opinions, and emotions [28]. Therefore, attitude can be defined as an extension of previously acquired knowledge, which itself originates from stimuli in the form of previously provided information [26]. Respondents had the opportunity to receive and comment on the foot care education they received through three rounds of AR and Animaker media. Because there is a window of time, during which they can decide which attitude is best for their health, individuals are more likely to accept the various inputs they receive. The respondents' desire to improve their health status and their education through the use of Animaker media, which provided explanations and illustrated how to care for one's feet through pictures, contributed to the change in attitude that occurred in all three groups. Education through the use of AR and video content that explains concepts and demonstrates how to care for one's feet can have a direct impact on respondents' actions [29]. Adding explanations and visuals to the Animaker combination can enhance learning through video and AR.

A change in attitude occurred in all three groups, partly due to the respondents' desire to use Animaker media to improve their education and health status. Animaker media provided explanations and images of how to take care of one's feet.

The actions of respondents may be directly influenced by the education provided through AR and video content that clarifies concepts and demonstrates how viewers should care for their feet [28]. AR and video learning can be enhanced by

incorporating explanations and images into the Animaker combination.

Before receiving education via AR media, Animaker, and a combination of the two, the three groups' levels of non-ulcer foot care behaviors were primarily in the poor category; however, after the intervention, the levels of non-ulcer foot care behaviors were primarily in the good category. The Wilcoxon test results for the three groups indicated notable variations between the behaviors observed prior to and following the intervention. Audiovisual media are useful tools when it comes to helping people with T2DM achieve ulcer-free feet [30]. After receiving education, a person's knowledge and attitudes can also change, and this process of changing behaviors follows; however, one can act or behave differently without first understanding the significance of the stimuli to which they are exposed [31]. Predisposing factors, such as views, values, and motivations to act, supporting factors, such as the availability of health facilities, and driving factors, such as the attitudes and behaviors of health professionals, families, or other officials who serve as role models for community behavior, as well as the health information they receive—including the media they consume—all influence an individual's behavior [32].

The information media used, namely Animaker, influenced changes in action, as it contains explanations and pictures of how to carry out non-ulcer foot care, which can serve as examples for respondents. Video and AR are more memorable because respondents not only see but also hear the information conveyed, and include moving images that are easier for respondents to understand and imitate [33]. Education provided through video/AR media, which features moving images about foot care steps and is complemented by sound, can stimulate the senses of sight and hearing, leading to better retention of information by respondents, specifically 50% [34]. The combination of Animaker media can positively influence changes in actions, serving as a complement for respondents who may be reluctant to turn on the video player. In this way, respondents will better understand and be more diligent in carrying out foot care actions because they have clear examples of the actions to be taken.

One of the limitations of the study was the possibility that differences in cultural beliefs or demographic characteristics (such as age, education level, and socioeconomic status) may impact how participants perceive and engage with the interventions, thereby affecting the study's overall findings. It is necessary to conduct similar research using more precise measurements, such as direct observation of non-ulcer foot care behavior in an effort to prevent diabetic ulcers in patients with T2DM. Additionally, it is important to examine factors that influence knowledge, such as sociocultural, economic, and experiential factors, factors that influence attitudes, such as social interactions and personal experiences,

and factors that influence behaviors, such as family support and health facilities.

Conclusion

The use of AR media, Animaker, or a combination of both increases knowledge, attitudes, and behavior in education about treating diabetic foot ulcers for prevention.

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