Efficacy of a Web Based Educational Program toward Knowledge Improvement in Diabetic Self-Foot Care Among Adults in a Limb Preservation Center with History of Previous Diabetic Foot Complications

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**Abstract**

 Diabetes is the leading cause of non-traumatic amputations and is generally preceded by a foot ulcer. Diabetic foot care is the simplest measure for ulcer and amputation prevention in adults with diabetes and associated neuropathy. Unfortunately, despite efforts to educate patients, there continues to be a lack of patient knowledge about foot self-care.

 The aim of this small pilot study was to explore the effect of a web-based educational intervention on knowledge improvement in diabetic foot self-care in patients with history of foot complications that have had previous foot care education. We wanted to explore whether or not our standard method of diabetic foot care education that has consisted of written and verbal face-to-face education was effective in this high-risk population. All patients in the study had been previously involved in this type of diabetic foot care education by a provider or wound nurse at least once. It was hypothesized that participants who viewed the video for their diabetic foot care education would be able to recall the information more accurately than before viewing the video.

 The intervention consisted of a 10-question true/false diabetes foot care knowledge pretest (10 points per question to equal 100) followed by a web-based Krames Staywell diabetic foot care video. This was then followed by a 10-question diabetes foot care knowledge posttest (identical to the pretest) to evaluate knowledge improvement. A total of twenty-one consenting participants were recruited for the study. All twenty-one participants completed the study. The outcome was assessed following the posttest. The findings indicated that knowledge was improved with the web-based intervention. Future research should include measures to evaluate outcome of knowledge gained in terms of reduction in ulcers and amputations. More research is also needed to determine how often this type of education should be provided to maintain self-care knowledge.

**Introduction**

 The American Diabetes Association (ADA) estimates that there are over 180 million people worldwide with diabetes, and this number is expected to double by 2030. In the United States, diabetes mellitus is also associated with foot ulcers and is the leading cause of non-traumatic lower extremity amputations (1,2,3).

 Diabetic peripheral neuropathy is a major contributor to foot ulcers. Neuropathy causes an insensate foot and often foot deformity, which can create an abnormal walking pattern and altered pressure points. These pressure points can become calloused and eventually break down to form ulcers. Limited joint mobility from neuropathy also causes problems with loading of the foot when walking. Minor trauma caused by ill-fitting shoes or walking barefoot can lead to chronic ulcers. It is estimated that up to 50% of people with diabetes have neuropathy and

at-risk feet. It is also estimated that 15% of all diabetic individuals will experience a foot complication such as an ulcer at some point during their life. More than 68,000 non-traumatic lower extremity amputations were performed on patients with diabetes in 2009, a rate that is eight times higher in patients with diabetes than in those who do not have diabetes. This is over 1000 amputations being done each week. Up to 80% of amputations are preceded by untreated ulcers (2,16). Furthermore, the mortality rate for patients undergoing amputation is 6%. In 2007, the treatment of diabetes and its complications in the United States was at least $116 billion, with at least 33% of these costs linked to the treatment of foot ulcers (2). According to the Centers for Disease Control, between 2009 and 2010, the percentage of US adults age 18yrs or older with diagnosis of diabetes who had attended an educational diabetes self-management class was only 57.4% and those who were having annual foot exams was only 67.5% (3,18).

 Foot health is essential in the management of diabetes, with foot care education being a priority. Studies have shown that educational interventions that focus on foot self-care measures such as skin and nail care, protective footwear and daily foot inspection improve patients’ foot self-care knowledge. This in turn helps to change foot care behaviors in high-risk individuals, which has been shown to reduce the occurrence of foot ulcerations and lower extremity amputations. (5,16). In a study by Lavery, (2010), it was suggested that the high rate of amputation in study participants was due to inherent risk for foot complications, but also a result of poorly utilized preventive services such as foot care education. The authors concluded that appropriate preventive foot care measures could have significantly reduced the high rate of amputations (8). In another study by Mooreland (2004), the author also indicated that preventive foot care such as education was related to a reduced rate of amputations (11). Johnson’s 2005 study suggested that patients must fully understand the impact of foot health in order to receive foot education. He also stressed the importance of patient-centered education that starts early into the disease process and is delivered with empathy by health care providers that could be trusted. Patients in this study reported feeling let down that their health care provider had not offered foot education until a foot complication had occurred or they required hospitalization for a foot ulcer or amputation. This was viewed as the result of patient attitude and acceptance of foot care advice in the early stages of diabetes, and/or varying skills and knowledge of health care providers. (6)

 A common problem associated with lack of preventative foot care education is that busy clinicians often do not have the time to fully educate patients on the principles and necessity of preventive foot care. It is widely recognized that primary prevention and health promotion activities lead to better outcomes; however, the workload in primary care hampers implementation of these measures (14). Web based education may be a better tool for delivering primary prevention and health promotion related to the diabetic foot to improve patients’ knowledge while also providing a convenient, time saving delivery for the clinician (4,9,12,14,19).

 With the development of Internet technology, web-based education is on the rise as an alternative method of teaching self-management skills associated with chronic diseases such as diabetes. Web-based educational interventions are used as a medium to provide patient education information through online mechanisms such as Internet websites (19). Approximately 84 million American adults use the Internet to search for health and medical information. The distribution of the online population is now significantly representative of the general population (12). Mitchell, et al. (2014) hypothesized that socioeconomic factors and health care access were responsible for differences in health-related Internet use in some populations, particularly African American men. However, the results indicated that nearly 40% of those participating in the study reported that the Internet was their most common source of health related information. The study also suggested that there was no relationship identified between health related Internet use and health care access (10).

 Lorig et, al. (2006), believes that web-based education saves time and money in the short term, with long-term benefits such as ulcer and amputation prevention. He furthermore suggests that many people have difficulty finding the time to attend diabetic foot care education classes, and prefer the convenience of web-based education (9). Web-based education can be self-paced and can provide an easy feedback system with no restrictions on time or location (17). A study by Ward, (1999) concluded that if education is going to be a part of diabetic foot ulcer prevention, the healthcare provider must establish a means for delivery that is easy, convenient and accessible for all patients (18). The time has come when patients, the consumer, are expecting to be more than recipients of care. Web-base education and health related Internet sites provide education for knowledge improvement of their disease process to help in health related decision-making and engagement in self-care (9,12,15).

 In a similar study by Gravely (2011), video diabetic foot education was compared with written educational materials for knowledge gained. The results of this study indicated that education provided by web-based videos was a more effective learning tool for a group of hospitalized patients with diabetes. However the author indicated that written methods in the group targeted may not provide adequate information for those with special needs such as seniors, minorities, or participants in poor health. It was further suggested that video education methods might also provide inadequate knowledge in some populations such as those with hearing loss, visual impairment, or limited attention span (5). Another study by Song (2009) reported positive findings with web-based education. This study noted that diabetic care behavior significantly improved, particularly when measured from 6 weeks to 3 months. This was attributed to participants in the Web group having the flexibility of visiting the website multiple times to find answers to their questions as well as social support from online peer groups (17).

**Kirkpatrick’s Four Levels of Learning Evaluation Theory**

 Kirkpatrick’s Four Levels of Learning Evaluation Theory was the framework for this study. This model stresses evaluation on the levels of reaction, learning, behavior, and results. This model is widely used not only in health management and education, but also in businesses such as Intel, Duke Energy and the military for targeting training-specific interventions. The model helps to identify the impact and effectiveness of courses so that strengths and weaknesses can be identified and improvements made. For the purposes of this study, Level 2, learning, was evaluated. Level 2 measures what the participants have learned and how much their knowledge has increased as a result of the intervention. There are several techniques to determine if the learning objectives have been met, such as performance testing or simulation (13). For the purposes of this study, performance testing in a pretest/posttest format was used. The participants were asked to display knowledge before and after the intervention.

**Methodology**

**Setting**

 As part of a quality improvement initiative, this study was conducted at the Novant Health Wound Care and Hyperbaric Center in Winston-Salem, North Carolina from April 2014 through May 2014. The primary investigator was one of the center’s nurse practitioners and certified wound specialist through the American Board of Wound Management, with 10 years of experience in wound management and diabetic foot care. The clinical advisor for the study was the center’s medical director, who is a vascular surgeon with 25 years of experience and who is also a certified wound specialist. The study consisted of three sections: 1) a pre-test to assess baseline knowledge of diabetic foot care; 2) a 7-minute web based diabetic foot care educational video; and 3) a post-test that was given after completion of the video to assess knowledge gained.

**Sample**

 The sample was a convenience sample of twenty-one patients at the Novant Health Wound Care and Hyperbaric Center with history of diabetic foot complications such as callouses, ulcers, or amputation. Each participant had previously been offered written and verbal diabetic foot education by the center’s staff at least once, as the policy of the center involves providing each new patient with a diabetic foot education packet. Inclusion criteria for the study included consented patients who were male or female, age 19-100 years. Characteristics also collected were length of time since diabetic diagnosis, history of previous callouses, ulcer or amputation, history of diabetic shoe use, BMI, and level of education completed.

 Patients who were unable to answer questions because of an altered mental state such as dementia were excluded from the study. Minors were also excluded from the study. While the disease and complications do occur in children, they are a much smaller percentage of the population. In this small pilot project, it was felt a better evaluation of the web-based intervention would be determined if the project focused on adults.

**Ethical Approval**

 IRB approval was granted through the University of Alabama and Novant Health. The principle investigator presented to the Nursing Research Committee for Novant Health for study approval. The primary investigator also completed CITI online training for the protection of human subjects in research.

**Data Collection**

 The patients were given a brief explanation of the study at check-in so they could make arrangements for an extended appointment time if they chose to participate. It was made clear that care would not be compromised whether they participated in the study or not. Those who agreed to participate were then presented with a more in-depth written explanation of the study. The primary investigator was available to offer additional verbal explanation. The consenting participants were escorted to an exam room and presented with the pretest. Results of the pretest were not provided to prevent influencing results of the posttest. The patient was then asked to view the 7-minute diabetic foot educational video using an iPad. This was immediately followed by the 10-question posttest to assess knowledge improvement. Participants were given feedback regarding correct and incorrect answer choices with brief explanation by the investigator.

 We chose to conduct the study at the beginning of the appointment time, while the patient waited to be evaluated by the provider. We felt this was more convenient for the patient in that the patient was receiving education during the wait time and would not be negatively influenced to hurry through the study at the end of the appointment. We also chose to address the important aspects of foot care in a brief, one-time 7-minute video session to respect the patients’ time and the clinic’s busy schedule.

**Intervention**

 Krames StayWell Patient Education produced the video. Novant Health uses Krames StayWell patient educational materials throughout its healthcare system. Krames StayWell content has been successfully integrated into the Epic electronic medical records system (EMR) at 39 hospitals and health systems, which includes Novant Health. The content of this video is evidenced-based and is endorsed by the American Diabetes Association. Some of the content covered included discussion and demonstration of foot health topics such as circulation, neuropathy, skin and nail care and foot wear (7).

**Questionnaire**

 The diabetic foot knowledge 10-question test was in English with interpreters available for non-English speaking patients and those who were hearing impaired. We also planned for visually impaired patients to be assisted by nursing staff. The twenty-one consenting participants who completed the study did not require these services.

 Following an extensive literature review, the primary investigator determined that there was not an appropriate diabetic foot knowledge test that would adequately assess knowledge gained from viewing his particular video. Therefore, the primary investigator developed a 10-question diabetic foot care questionnaire specific to the video content. This served as the pretest and posttest. The instrument was tested on 3 patients prior to beginning the study to assess understanding. Five nurse experts in foot care reviewed questions to assess content validity. The nurses were either certified wound specialists or certified wound ostomy continence nurses and staff members at the Novant Health Wound and Hyperbaric Center. Paired pre-and post-test questions inquired about diabetic foot topics such as: 1) proper footwear; 2) foot inspection; 3) circulation; 4) neuropathy; 5) foot infections; and 6) amputation risks (Figure 2).

**Data Analysis**

 The outcome variable of the study was diabetic foot care knowledge. Descriptive statistics was used to examine demographics and clinical characteristics of the participants. Data collected included age, BMI, previous callouses, ulcers or amputation, time since diabetes diagnosis, level of education completed and use of diabetic shoes. The pretest- posttest model was used to assess the effectiveness of the web-based diabetic foot educational intervention toward knowledge improvement. A measure of central tendency to measure the mean was used to compare the pretest posttest knowledge performance. T-test was used to compare the means of the scores.

**Characteristics of Participants**

Twenty-one consented participants enrolled in the study and completed the pretest and posttest. The average age of the participants was 65.61. The youngest participant was 40 and the oldest participant was 89. All twenty-one participants admitted to having participated in some level of diabetic foot education previously. The average amount of time since diabetes diagnosis was 14.09 years. The lowest number of years was 2 and the highest number of years was 29. Average BMI was 35.5. The lowest BMI was 17.0 and the highest BMI was 63.0. Twelve participants (57.1%) had history of previous diabetic foot ulcers and fourteen participants (66.7%) indicated history of foot callouses. Four participants (19.0%) had history of a previous digit or limb amputation. Only seven participants (33.3%) admitted to regularly wearing diabetic shoes while fourteen participants (66.7%) indicated they had never owned diabetic shoes or owned them but did not wear them regularly. All participants (n=21) were asked about their highest level of education completed; two (9.5%) were college graduates, seventeen (81%) were high school graduates and two (9.5%) had completed a GED (Figure 3).

**Results**

 Completion of the web-based video was associated with improvement in diabetic foot care knowledge. The mean difference of 13.80% in knowledge improvement of all participants (n=21) following the intervention showed that the pre-test / post-test scores were statistically significant (Figure 4) with the p-value < 0.001. Those participants who reported a previous amputation (n=4) scored slightly higher on the pretest (70%) than those who reported no amputation (n=17), (65.88%). Posttest scores for those with history of amputation (n=4) were slightly lower (80.00%) than those with no amputation (n=17) history (80.58%). Participants with previous foot ulcers (n=9) scored higher on both pretest (67.77%) and posttest (81.11%). Those who reported no previous ulcer (n=12) scored lower on pretest (65.83%) and posttest (80.00%). Participants with no reported callous (n=7) scored higher on the pretest (67.14%) compared to the pretest scores for those who reported callous (n=14), (66.42%). Posttest scores for this group were higher in the group who reported callous (n=14), (81.42%) than the group with no callous (n=7), (78.57%).

 Higher levels of education correlated with higher pretest scores. College graduate (n=2) pretest scores were 80.00%. High school graduate (n=17) pretest scores were 65.29% and GED (n=2) pretest scores were the lowest at 65.00% There was no difference in college graduate (n=2) and GED (n=2) graduate posttest scores (85.00%) with high school graduate (n=17) having the lowest posttest score (79.41%). Those participants who regularly wore diabetic shoes (n=7) scored higher in the pretest (70.00%) and posttest (81.42%). Those who did not wear diabetic shoes (n=14) scored lower in the pretest (65.00%) and posttest (80.00%).

**Discussion**

In this study, web-based education appeared to provide enriched learning that was fun and interactive for patients, family, and staff. It was also convenient and easy to deliver. If diabetic foot care education is going to be effective, programs must be flexible and offered at convenient times for the patient and not limited to convenience of clinic staff or institution schedules (15).

 Knowledge of appropriate foot care has been shown to positively influence patients to become more engaged in self-foot care. Knowing what the participants are learning can help to guide future educational models. This is paramount to preventing ulcers and amputation and should be regularly reinforced (3,16). Enhanced learning possibilities with web-based education may be a valuable tool in increasing access for diabetic foot care education, thereby increasing potential for knowledge improvement toward behavior change and self engagement of foot care (15, 17).

**Limitations**

 While this his study’s results appear to show the value of using a web-based program for teaching foot care, it only applied to a specific group of patients at a specific point in time. In reality, there may be a knowledge divide when technological competency and digital literacy are considered.More research is needed to study the effect of other web-based diabetic foot teaching models towards knowledge improvement in a wider population to validate its effectiveness.

The study also did not address the issue of diabetic foot care knowledge retained. Patients often perform well immediately after receiving education, but fail to retain the information if they are not given reinforcements. It is not clear at what interval booster education should be offered to maintain knowledge (16, 17.)

 Although this study demonstrated diabetic foot care knowledge gained from the web educational intervention, it was not designed to address its role in reducing foot ulcers and amputations. Therefore, no definitive conclusion regarding outcomes can be drawn from this study. Further research would be needed to determine whether knowledge gained from such an intervention translates to improved outcomes in the diabetic foot.



Fig: 1 Kirkpatrick’s 4 Levels of Learning Evaluation Model

**Diabetic Foot Care Knowledge Pretest / Posttest**

1. Foot wounds are the most common cause of hospitalizations for people with diabetes. True\_\_\_False\_\_\_
2. People with diabetes should not soak their feet. True\_\_\_False\_\_\_
3. Proper footwear can help to prevent diabetic foot ulcers. True\_\_\_False\_\_\_
4. Call your healthcare provider if small wounds do not heal within 1 week. True\_\_\_False\_\_\_
5. Approximately 1,000 leg amputations are performed every week as a result of foot wounds. True\_\_\_False\_\_\_
6. High blood sugar levels increase the risk of neuropathy (nerve damage), poor circulation, and infection. True\_\_\_False\_\_\_
7. Shoes to avoid include pointed toes, high heels, flip-flops, and plastic shoes such as crocs. True\_\_\_False\_\_\_
8. Feet should be moisturized with lotion or Vaseline nightly to include the top and bottom of the foot, the heels, and between the toes. True\_\_\_False\_\_\_
9. It is recommended to always wear shoes when going outside, while going barefoot only inside the house. True\_\_\_False\_\_\_
10. It is best to gently trim callouses or corns with scissors or a blade following a shower or bath. True\_\_\_False\_\_\_

Fig: 2 True/False Pretest/Posttest questions posed to patients

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*Demographic and Clinical*

*Characteristics Of Study Participants (n=21)*

**Age, mean (range) 65.61 (40-89)**

**BMI, mean (range) 35.52 (17-63)**

**Diabetic Years mean (range) 14.09 (2-29)**

**Level of Education College=2, High Sch=17, GED=2**

**History of prior foot care education 100%**

**History of Foot Ulcer 9=yes 12=no**

**History of Amputation 4=yes 17=no**

**History of Foot Callouses 14=yes 7=no**

**History of Diabetic Shoes 7=yes 14=no**

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**|**Fig: 3 demographics and clinical characteristics  **|**

| |Fig: 4 Pretest/Posttest Diabetic Foot Care Knowledge Scores | |

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