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Research Article

The Effectiveness of a Mobile Nutrition Application to Promote the Nutritional Status and Wound Healing Rate in Patients with Pressure Ulcers Receiving Long-Term Care in Thailand

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Abstract

This innovative developmental research study aims to determine the effects of a mobile nutrition application on the nutritional status and wound healing of 72 immobilized patients in long-term care in Thailand. The patients were randomized into two groups, a control group receiving conventional care and an experimental group using the mobile nutrition application. A personal information record, a wound-healing rate evaluation form, and a record of blood albumin levels were analyzed using descriptive statistics and t-test. The results showed that the wound-healing rates and blood albumin levels of the experimental group were significantly higher compared to those of the control group ($p < 0.05$). The results suggest that the use of this application could promote the nutritional status in patients with pressure ulcers and significantly enhance the satisfaction of caregivers. This application for daily energy and food intake calculations can be used as an effective health-associated innovation that promotes the nutritional status monitoring of patients and also provides caregivers with knowledge and understanding for improving the nursing care of patients.

Keywords: Nutrition applications, Nutritional status, Pressure ulcers

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Background and Significance

Pressure ulcers are a major public health problem and have many impacts on patients and their families, healthcare costs, and the global health system [1], especially in Thailand where the prevalence of pressure ulcers in public tertiary care hospitals is around 1.7 per 1,000 persons per year [2]. Pressure ulcers are a complication for elderly and immobilized patients in all settings, especially in the community [1]. In Thailand, a study of Mamom demonstrated that 90% of pressure ulcers occurred among adults receiving home-based care in the rural community [3]. Home-Acquired Pressure Ulcers (HAPU) are a frequently and serious problem that contribute to increased morbidity and mortality among adults and elderly in home-based care [4]. The pressure ulcers that occur among individuals receiving home-based care are often due to patients' medical conditions and the caregivers' workload, and thus are difficult to prevent, especially among immobilized patients [4]. Elderly patients often have malnutrition and thereby lack proteins, carbohydrates, fats, vitamins, and/or minerals. Vitamins A, C, E, and water are not only involved in but also promote the wound healing process [4].

Body proteins are an important component that are used in the repair of many tissues [5] by facilitating new blood vessel generation (neovascularization), tissue regeneration (fibroblast), collagen fiber synthesis, and immune system function through the cell-mediated response in the phagocytosis process [6]. Under normal conditions, elderly people require 1 gram of proteins/kilogram of body weight but, when they have pressure ulcers, their bodies need more than 2 grams of proteins per kilogram of body weight [7]. Carbohydrates and fats act as protein-sparing agents and help to promote the functions of leukocytes and fibroblasts, making white blood cells work better so that infections are reduced and wound healing is more rapid [8]. Carbohydrates and fats also provide energy to cells and are essential for leukocyte agglutination. If carbohydrates and fats are deficient in number, protein degradation will occur in the supply of energy [8]. When pressure ulcers develop, the body's energy requirements increase to 35 kilocalories/kilogram of body weight [9]. Since the energy that the body uses should be derived from carbohydrates and fats, energy calculation is based on carbohydrates and fats only, excluding the energy from proteins in order to maintain the body weight. Under normal conditions, our body needs 20-25 kilocalories of energy/kilogram of body weight. Essential minerals, including sodium, potassium, chloride, calcium, and phosphorus, are not only important for collagen synthesis and tissue formation but are also used to maintain normal cellular functions and water homeostasis. The balance of salts and water is important in maintaining blood circulation in tissues [10]. Zinc is involved in the RNA replication process, which is important for cell proliferation. Under normal conditions, our body needs 15 milligrams of dietary zinc/day. When ulcers develop, the body's zinc requirements increase to 225 milligrams/day [9]. Zinc deficiency may cause abnormal lymphocyte functions, resulting in increased risks of infection [11]. Vitamin C is essential for collagen bundling and helps with infection prevention, collagen synthesis, new capillary generation, and blood vessel strengthening so that they are not fragile.

In addition, it plays an important role in neutrophil functions. Vitamin C deficiency increases the risks and severity of septic wounds [12]. Vitamin A not only promotes collagen synthesis and cell proliferation, but also stimulates macrophage recruitment around the wound and reduces wound infection. Aqueous materials help maintain the blood circulation system and promote skin integrity. Thus, patients should take at least 2,500 milliliters of water/day if there are no other exceptions [10].

Currently, malnutrition is a problem that has not been systematically tackled, and therefore, promoting the nutritional status of patients with ulcers is very important. Malnutrition causes wounds to heal slowly and they can easily turn into chronic ulcers, thereby affecting the family, society, and the health system. Therefore, the management of various factors that help prevents wounds and enhances their healing, especially nutritional status promotion [12], is extremely important. A number of studies have confirmed that malnutrition increases the incidence and degree of pressure ulcers by 2.8 times over those with normal nutritional status [13]. In addition, malnutrition also causes regenerated tissues to lack strength and increases infection rates [14]. The principle of nutritional status promotion in patients with pressure ulcers is to provide complete nutrients as required by each patient. However, food preparation procedures are rather complicated, cumbersome, and multi-step, making it difficult for relatives to care for patients so they do not place importance on the preparation of complete and correct raw materials [3]. This could be the reason underlying the increased incidence of pressure ulcers in community patients.

At present, mobile devices are becoming increasingly important due to their advantages of portability, wireless connection, and light weight. For these reasons, mobile devices have become an indispensable part of daily life. In Thailand, there are no mobile applications that calculate individualized daily energy needs and provide information on the specific nutrients required for each individual to promote the nutritional status of patients with pressure ulcers. However, a large number of supportive mobile apps are being developed to help improve quality of life. Hence, mobile devices and their applications are becoming tremendously important, which will also bring about great change in the healthcare management area. Both the iOS and Android platforms were chosen for our development of a mobile nutrition application to help caregivers calculate the daily energy and food intake off patients in order to improve their nutritional status and to increase their wound healing rate. The application was written in the Objective-C programming language with Code as the integrated development environment.

Research Objectives

1. To compare the nutritional status between the groups was using the mobile nutrition application and the group receiving conventional care.

2. To compare the nutritional status before and after using the mobile nutrition application.

3. To compare the wound healing rates between the groups using the mobile nutrition application with the group receiving conventional care.

4. To compare the wound healing rates before and after using the mobile nutrition application.

Research Design

The experimental research design was used to study the effects of the mobile nutrition application on the nutritional status and wound healing rate of community patients with pressure ulcers. The subjects were patients with pressure ulcers that had caregivers possessing a mobile phone that could access the application and that were allowed by their doctors to return to home-based care from April 2016 to December 2017. The inclusion criteria were as follows:

1. Patients with all degrees of pressure ulcers that were allowed returning to home-based care.

2. Enteral feeding was prescribed by their doctors.

3. Caregivers could use the application and communicate in Thai correctly.

4. They had no mental disorders.

5. They were willing to participate in the research.

Sample Size Calculation

In this study, the sample size was calculated by power analysis using the G*Power program [15]. The alpha value was assigned to 0.05, along with power = 0.8, medium effect size (w) = 0.6.The test was one-tailed. The sample size of 72 subjects was divided into 36 subjects in the experimental group and 36 subjects in the control group using matched pairs based on gender, age difference of up to 5 years, same stage of pressure ulcers, and having family members as caregivers.

Research Instrument consisted of two parts:

Part 1: The data collection tools were as follows.

1. Wound healing rate was assessed using the Pressure Ulcer Status Tool (PUSH), which assessed the progression of wound healing in order to detect the different wound size, the amount of secretion, and the wound base appearance. According to the PUSH tool criteria, the maximum score of 17 points indicates a bad wound that heals slowly, where as the minimum score of 0 points indicates that the wound has fully recovered. Wound healing rate was documented on the first and 28th days of enrollment (regularly follow-up schedule for this population).

2. Nutritional status assessment was performed through blood albumin level determination according to the standard method [16] by using 5 milliliters of blood serum. The assessment was carried out by the investigator on the first and 28th days of enrollment.

Part 2: The tools for conductingthe research included the application for calculating the required daily food intake, which is an operating system that could be accessed by the caregivers on their phones to calculate the energy and food required per day. Both the iOS and Android platforms were chosen to develop the mobile nutrition application that helpedthe caregivers with the calculations of the daily energy and food intakeof the patients in order to improve their nutritional status and to increase the wound healing rate. The application was written in Objective-C programming language with X-code as the integrated development environment. The application work procedure consisted of the following steps.

Step 1: Fill in personal information,including name, age, weight, height, stage of pressure ulcers, so that the system cancalculate the output as theenergy required bythe patient per day.

Step 2: The system calculated the nutrient requirements in each of the five food groupsin order for the patients to receive complete nutrients-by using the equation for Total Energy Expenditure (TEE) = BEE x 1.2 x stress factor.

In males

BEE = 66 + (13.7 x weight [kg] + (5 x height [cm]) - (6.8 x age).

In females

BEE = 655 + (9.6 x weight [kg] + (1.7 x height [cm]) - (4.7 x age). Stress factor in patients with pressure ulcers.
1st and 5th degree of pressure ulcerstress factor = 1.0.
2nd-4th, 6th degree of pressure ulcerstress factor = 1.15.

Step 3: The system displayed the amount of nutrients in each food group as calculated in Step 2.

Step 4: The system displayed the food categories that provide the calculated energy.

Food formula for anyone who needs 1,017 k cal consists of 61 grams, 34 grams, 117 grams and 545 mgs of protein, fat, carbohydrates and cholesterol respectively. After that, the system will display the list of raw materials belonging to each group of energy sources e.g. (1) raw materials for protein: pork, beef, chicken or fish; (2) raw materials for fat: vegetable oil; (3) raw materials for carbohydrates: sugar, cooked rice; (4) raw materials for cholesterol: eggs; (5) other raw materials: green, yellow vegetables such as kale, gourd, cantonese, pumpkin or carrot. Finally, water must be added to get the final volume of 1,000 cc. The calculated amount of each raw material will lead to the desired final energy of 1,017 kcal for one patient per day.

Evaluations of research instruments

Determination of tool reliability: The reliability of the PUSH tool was determined by the investigator by using it with 10 patients with pressure ulcers, who had the same qualifications as those of the study subjects. The resulting scores were analyzed for tool reliability using the equation for Cronbach's alpha coefficient, which was 0.92.

Research data analysis

1. The personal status information of the subjects was analyzed for-percentage frequency distribution, mean, and standard deviation.
2. Comparison of the nutritional status between the group using the mobile nutrition application and the group receiving regular nursing care was based on independent t-test statistics.
3. Comparison of the nutritional status of the experimental group before and after using the mobile nutrition application was based on paired t-test statistics.
4. Comparison of the wound healing rates between the group using the mobile nutrition application and the group receiving regular nursing care was based on independent t-test statistics.
5. Comparison of the wound healing rates of the experimental group before and after using the mobile nutrition application was based on paired t-test statistics.

Procedure of the Intervention and Data Collection

Seventy-two participants were randomly allocated to intervention group 1 (n=36) and the control group (n=36) using the SPSS V 0.24 random number generator for an equivalent participants' amount in each group.

In intervention groups, the researcher educated them overall about PUs, the method of PUs prevention, nutrition care, and how to calculate energy and food per day according to this application and gave a demonstration and return demonstration until the researcher was certain that the caregivers were able to use and manage the application appropriately. Meanwhile, in the control group, the researcher educated them overall about PUs, the method of PUs prevention, nutrition care, and how to calculate energy and food per day according to the manual from the nutrition department and gave a demonstration and return demonstration until the researcher was certain that the caregivers were able to calculate energy and food appropriately.

Results

Part 1: The general characteristics of the subjects were as follows. The sample size was 72 subjects between 48-66 years of age. The average age was 55.38 years (SD = 3.96). Most subjects were female (52 subjects, 79.2%). Thirty-five subjects (48.6%) were married, while 34 (47.2%) were widowed/divorced/separated and 3 (4.2%) were single. Their family income was mostly sufficient, and 40 subjects (55.6%) had savings. Thirty-six subjects (44.4%) had government employee health benefits, whereas 32 subjects (44.4%) had universal healthcare coverage (30 baht).

Part 2: Comparison of the blood albumin levels between the experimental group using the mobile nutrition application and the control group receiving regular nursing care indicated that the blood albumin levels of the group using the mobile nutrition application were significantly higher than those of the control group receiving regular nursing care at the 0.05 level.

Part 3: Comparison of the blood albumin levels before and after using the mobile nutrition application showed that the blood albumin levels of the experimental group after using the mobile nutrition application were significantly higher than before the mobile nutrition application was used at the 0.05 level.

Part 4: Comparison of the PUSH scores between the experimental group using the mobile nutrition application and the control group receiving regular nursing care demonstrated that the blood albumin levels of the group using the mobile nutrition application were significantly higher than those of the control group receiving regular nursing care at the 0.05 level.

Part 5: Comparison of the wound healing rates before and after using the mobile nutrition application.

Results for Part 5: Comparison of the PUSH scores before and after using the mobile nutrition application showed that, after using the mobile nutrition application, the PUSH scores of the experimental group were significantly higher than before the mobile nutrition application was used at the 0.01 levels.

Discussion of the Results

General characteristics of the subjects

The subjects in this study were mostly female (79.0%). The mean age was 55.38 years, while the age range was between 48-66 years, which is similar to that of the population with pressure ulcers, who

are usually elderly. These findings agree with the study of [3,4,17], which revealed that patients with pressure ulcers had a renege of age 50-60 years (SD = 7.65-10.76) and were mostly female. In contrast, the study of which explored the incidence, risk factors, and characteristics of pressure ulcers, showed that most patients were male with the ages between 70-90 years [18-20]. This is because elderly people have reduced muscle mass, decreased dermal collagen synthesis and reduced body movement, resulting in prolonged pressure on their skin until the pressure ulcers are formed. In addition, they also have some diseases or disorders that reduce blood flow so nutrients and oxygen cannot be adequately supplied to cells. In addition, most elderly patients have malnutrition due to lack of protein, carbohydrates, fats, vitamins, and minerals that are related to the wound prevention process and promote wound healing.

Significance of the application for calculating required daily food intake in terms of nutritional status

This application for calculating the required daily food intake is different from other applications in general because it can calculate the required energy specifically for each patient. The system will calculate the nutrient requirements for the 5 food groups so that patients receive complete nutrients. Then, the system will display the calculated amounts of nutrients in each food group along with the food categories that provide the calculated energy. In this way, caregivers can prepare complete and correct food for patients according to the requirements of each patient, which affects blood albumin levels that in turn affect nutritional status. It was observed that the blood albumin levels of the 36 subjects using the developed application for calculating the required daily food intake increased from 2.51 to 2.75 mg% after their caregivers used the developed application. When compared to the subjects using the regular nutrient calculation guide, the average blood albumin level of the subjects using the application for calculating the required daily food intake was 2.75 mg% while that of the subjects using the regular nutrient calculation guide was 2.54 mg%. People in this era have very good knowledge and skills in using applications, and in this case the use of this application can help them improve their nutritional status and consequently make their pressure ulcers heal faster.

Significance of the application for calculating the daily energy and food intake in relation to wound healing rate

This application for calculating daily energy and food intake enables caregivers to prepare food for patients so that they can get complete and accurate nutrients in each food group for each patient, resulting in increased blood albumin levels and higher wound healing rates. It was observed that the 36 subjects using the developed application for calculating the daily energy and food intake had better PUSH scores, which decreased from 11.39 to 9.61. When compared to the subjects using the regular nutrient calculation guide, it was found that the wound healing rate of the subjects using the regular nutrient calculation guide was 10.81 points, while for those using the application for calculating the daily energy and food intake it was 9.61 points. This is because nutritional status promotion is a factor that enhances wound healing [7]. In previous literature, malnutrition has been shown to affect the occurrence and degree of pressure ulcers 2.8 times over those with normal nutritional status [13]. In addition, regenerated tissues also lack strength and infection rates are increased [21]. Therefore, malnutrition of patients before or during wound

formation will slow down the wound healing process [21]. The systematic reviews of Cereda et al.,-2017 [9] to collect empirical evidence on the efficiency of nutritional status promotion demonstrated that nutritional status promotion, especially in the groups of proteins, argentines, zinc, and antioxidants, significantly increased wound healing rates (p = 0.030) [22].

Features of the application for calculating the required daily food intake that affects nutritional status and wound healing rate

At present, mobile phone devices are extremely successful worldwide, and mobile phone applications are becoming a necessity in everyday life and are widely used by people of both genders and of all ages. A number of health-related applications are published on leading platforms, both iOS and Android. The developed application for calculating the required daily food intake is a mobile application that can facilitate energy calculation for individual patients. It was observed that the 36 subjects using the application for calculating their required daily food intake improved their nutritional status and wound healing rates when compared to the control group receiving regular nursing care. The results from this study are consistent with the study of Patel et al on the effects of using a mobile application to automatically remind hypertensive patients to take their medication [23]. Their three-month study revealed that, while participating in the research on this application, the medication adherence scores were significantly increased. Hantsoo et al., studied the effects of a mobile application on improving mental healthcare delivery [24]. Their eight-week study showed that the patients that used the application significantly increased their rated ability to manage their own health as compared with the women in the control group (p < 0.001). Additionally, Zhao, Freeman, and Li studied the effectiveness of mobile applications on health behavioral changes as revealed in articles published from 1 January 2010 to 1 June 2015 in databases, including Medline, Pre Medline, PsycINFO, Embase, Health Technology Assessment, Education Resource Center, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), and the Journal of Medical Internet Research [25]. Out of 23 articles, 17 of them showed that applications were efficient in changing health behaviors [25]. However, it was also found that the application features still required continuous development, such as the duration and speed of access to the program.

Apart from the direct effectiveness on changes in health factors, the developed application for calculating the required daily food intake is also satisfactory for users. It was found that the caregivers of 36 patients were satisfied with the application for calculating the required daily food intake at the highest level (average 4.51 points). This agrees with the satisfaction theory of Miremberg and colleague, which indicates that satisfaction results from the interaction between users and the service provider that can make users feel positive about the service or innovation that they use, making the users more willing to follow all the steps in the program [26]. As a result, the relatives that used this application prepared correct food so the patients received complete nutrients, thereby having increased album in levels, improved nutritional status, and faster wound healing when compared to the group receiving regular nursing care.

The developed application for calculating required daily food intake is efficient in promoting nutritional status, which consequently makes wound healing faster. This easy-to-use and uncomplicated

application was created in conjunction with direct person-to-person education, demonstration, and reverse demonstration in order to ensure that, when returning home, it can be properly implemented by the patient or caregiver, along with symptom follow up at home for continuity of care. This will help patients and relatives/caregivers know, understand, and be able to apply their knowledge to correctly adjust their healthcare behaviors. Thus, the relatives/caregivers will feel that they are a part of the healthcare team, resulting in the desired patient care outcomes. Education along with the creation and application of knowledge in order to lead to innovation is very important at present. If patients and relatives have knowledge and understanding regarding the prevention of pressure ulcers, they can behave correctly. As a result, the occurrence of pressure ulcers in hospitals or when patients are at home will decrease.

Recommendations

Mobile application usage can increase the potential for food preparation to promote nutritional status, which takes only 4 months. Therefore, this mobile application can be installed for patients that are allowed to return to home-based care with the availability of a smart phone. It is also a means to develop the potential of patients and families to prepare food and to promote nutritional status in order to facilitate the recovery of pressure ulcers at home in patients with pressure ulcers in long-term care.

Acknowledgments

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