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Effects of an herbal foot bath to reduce foot paresthesia among diabetic patients with complications in border area of Sa Kaeo, Thailand

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ABSTRACT

Foot complications from diabetes, particularly numbness, can be managed using traditional Thai medicine. This alternative approach incorporates various herbs to relieve numbness in the feet. This study investigated the mean change in visual analog scale (VAS) scores and monofilament test results among diabetic patients with complications. The research employed a quasi-experimental design with a two-group pretest-posttest design involving diabetic patients with complications. The sample consisted of 72 participants, divided into intervention (n = 36) and control (n = 36) groups through simple random sampling. The control group received standard care and a self-care foot manual. In contrast, the experimental group participated in a four-week herbal foot bath program, three times a week, totaling twelve sessions. Following this, they were monitored for three months, continuing to use the herbal foot bath once a week. Data were analyzed using descriptive statistics, paired t-tests, and independent t-tests. The findings indicated a significant reduction in mean VAS scores for the left foot in the intervention group compared to the control group. Moreover, there was a notable reduction in mean VAS scores for the right foot in the intervention group compared to the control group. Additionally, the monofilament test revealed a significant decrease in the mean number of points with numbness in the left foot for the intervention group compared to the control group. Similarly, there was a significant decrease in the mean number of points with numbness in the right foot between the intervention and control groups. These results suggest that the herbal foot bath may serve as an effective and accessible non-pharmacological intervention for managing diabetic foot paresthesia in community healthcare.

Keywords: Thai traditional medicine; paresthesia; diabetes; visual analog scale; herbal

1. INTRODUCTION

The global prevalence of diabetes mellitus has been extensively reported extensively by the World Health Organization (WHO). According to the latest data from the WHO in 2021, approximately 450 million individuals were have been diagnosed with diabetes. This number is projected to increase to 537 million in 2022, 677 million in 2023, and 830 million by 2024. The rising prevalence of DM highlights the growing burden of this disease worldwide. This significant increase underscores the urgent global health crisis posed by diabetes and emphasizes the need for effective prevention and management strategies (World Health Organization, 2024). Specifically, Thailand has observed a concerning upward trend in diabetes mellitus (Diabetes Association of Thailand, 2023), with 300,000 new cases reported annually and 3.3 million individuals currently enrolled in the system. In 2023, there were a total of 16,388 deaths, resulting in a mortality rate of 25.1 per 100,000 population (Diabetes Association of Thailand, 2023). In Sa Kaeo province, the occurrence of non-communicable diseases, especially diabetes, has been increasing. The number of diabetes patients has risen from 26,627 in 2021 to 27,959 in 2022, and 29,322 in 2023, showing a consistent increase in the number of patients over the past three years (Sa Kaeo Provincial Public Health Office, 2023).

Diabetes can lead to complications, particularly foot-related issues (Patti et al., 2022). Several risk factors influence the onset of diabetes, including improper dietary habits and lack of exercise, which can result in illnesses and complications (Thipsawat, 2021) such as diabetic retinopathy, chronic kidney disease, cardiovascular disease, chronic wounds, and amputations of the foot and toes (Zhu et al., 2024). According to the Department of Disease Control, 5.0% of diabetic patients have foot ulcers, and 1 in 6 has had at least one ulcer (Department of Disease Control, 2019). Foot problems in diabetic patients are a significant cause of hospitalization, adversely affecting the patient's quality of life and increasing public health costs (Al Amri et al., 2021).

Diabetes can lead to foot complications caused by narrowed blood vessels that supply the feet, resulting in insufficient blood flow. This can cause wounds due to inadequate blood supply and pressure sores from inflamed nerves (Ziegler et al., 2021). These issues may increase the risk of patients needing foot amputation. Moreover, diabetic patients are at higher risk of developing nerve degeneration and insufficient blood flow to the feet, which can cause foot wounds (Ziegler, 2023). The treatment of foot complications from diabetes, particularly numbness in the feet, can be managed through modern medicine and alternative medicine, such as traditional Thai medicine, which involves using various herbs to reduce foot numbness in diabetic patients with complications (Andrade et al., 2020).

Importantly, the number of diabetic patients in Ta Phraya District, Sa Kaeo Province was 2,290 cases in 2021. This figure increased to 2,523 cases in 2022 and 2,655 cases in 2023, indicating a rising trend over the past three years. Additionally, during the annual health screening conducted by the Health Promotion Hospital in Thap Sadet sub-district, Ta Phraya district, Sa Kaeo province, the number of identified diabetic patients was 255 cases in 2021, which rose to 322 cases in 2022 and 355 cases in 2023 (Thap Sadet Sub-district Health Promoting Hospital, 2023). According to the findings of foot numbness screening using the monofilament, 70.0% of diabetic patients experienced numbness in at least one area (Thap Sadet Sub-district Health Promoting Hospital, 2023). The condition has the potential to lead to foot complications, wound formation, and even amputation. This study aimed to examine the effects of herbal foot baths on reducing foot paresthesia in diabetic patients with complications in the border areas of Sa Kaeo province, Thailand.

Traditional Thai medicine has long incorporated herbal remedies for managing neuropathic symptoms. Herbal foot baths are believed to improve circulation, reduce inflammation, and enhance nerve function by utilizing medicinal plant extracts with known therapeutic properties, such as plai and turmeric rhizome. These herbs possess anti-inflammatory, analgesic, and vasodilatory effects, which may contribute to symptom relief in diabetic neuropathy. In this study, the researchers developed an herbal foot bath formula that differs from existing research (Fan et al., 2018). A review of related studies revealed various herbal foot bath formulas, with each type of herb having different cultivation sources (Raksamat & Thongon, 2020). This study uses 80 grams of plai, a higher amount than in other studies, which typically use only 50 grams. The increased quantity of plai might enhance the effectiveness of reducing foot numbness (Preecha et al., 2022). Additionally, most related studies employed a four-week foot bath protocol, with participants soaking their feet thrice weekly, effectively reducing foot numbness (Honnonprai et al., 2020). However, this study designed a protocol where participants soaked their feet for four weeks, three times per week, and then continued to monitor the results for another four weeks, washing their feet once a week for three months. Moreover, this study incorporates community participation, where village health volunteers (VHVs) are responsible for recording and monitoring each patient's foot bath sessions. VHVs also record the results and change the herbal foot soak mixture each week.

In Thap Sadet sub-district, a border area between Thailand and Cambodia, many households grow medicinal plants for personal use, often incorporating them into food preparation. The researchers aimed to add value to these local herbs by developing an herbal foot bath program to reduce foot numbness in diabetic patients with complications (Wanchai & Phrompayak, 2016; Rafi et al., 2020). The herbs used in this program include plai rhizome, tamarind leaves, kaffir lime peel, turmeric rhizome, and lemongrass. These herbs have properties that help relieve muscle pain, stimulate blood circulation, relax muscles, reduce foot numbness, and relieve stress through the aroma of spices that contain essential oils. The findings of this study will serve as a guide and process for addressing foot numbness using herbal remedies, as well as helping diabetic patients with foot complications manage their conditions. The herbal foot bath can be adapted to a health care activity using traditional Thai medicine as an alternative treatment for diabetic patients.

2. MATERIALS AND METHODS

2.1 Study design, population, and samples

This study was a quasi-experimental research using a two-group pretest-posttest design to evaluate foot numbness scores (visual analog scale; VAS) and the number of numb points in both feet using a monofilament test in diabetic patients with complications. The research compared the experimental group and the control group before and after a three-month follow-up. The experimental group participated in a four-week herbal foot bath program, soaking their feet three times per week for twelve sessions. They were then monitored for three months, during which time they continued the herbal foot bath once a week for another twelve sessions. The control group received standard care and a self-care foot manual. Both groups were evaluated twice: before the experiment and after a three-month follow-up between February and May 2024.

The population of the study comprised 335 diabetic patients in Thap Sadet sub-district (Thap Sadet Sub-district Health Promoting Hospital, 2023). The samples included diabetic patients with complications who experienced foot numbness. The G*Power program was used to calculate the sample size, which was determined based on an independent two-group mean comparison. The test family selected was t-tests, with the statistical test set to "means: differences between two dependent means (two groups)" using a two-tailed approach. The effect size of 0.72 was derived from a relevant literature review (Meizhen et al., 2023), with an alpha level of 0.05, statistical power (beta) of 0.85, and an allocation ratio (N2/N1) of 1. This resulted in a required sample size of 36 per group, totaling 72 participants.

2.2 Sampling technique, inclusion, and exclusion criteria

Participants were selected through simple random sampling. Each participant was assigned a number from 1 to 335, and a lottery was conducted without replacement. If a selected sample group did not meet the inclusion criteria, a new random draw was conducted until the full sample size of 72 participants was achieved. The sample was divided into two groups of 36 participants each through another random draw. To minimize bias, all participants were screened before enrollment to ensure they had not received similar foot bath interventions in the previous six months. Additionally, medical records and pre-study interviews were reviewed to confirm that no concurrent treatments targeting diabetic neuropathy had been received during the study period. This process helped ensure that the effects observed in the study could be attributed solely to the herbal foot bath intervention.

Inclusion criteria included participants diabetic patients with complications who received treatment at the primary healthcare unit in Thap Sadet sub-district, located in a border area between Thailand and Cambodia. Eligible participants were required to have a foot numbness score of 4 or 5 on the VAS and demonstrate numbness in at least one location, as determined by monofilament testing. Exclusion criteria included patients with other chronic conditions that prevented them from participating in the program, such as coronary artery disease, osteoarthritis, and osteoporosis, were excluded. Additionally, patients who experienced diabetes-related complications during the study were also excluded.

2.3 Intervention details

The herbal foot bath program was developed based on Orem's self-care theory (Punjani, 2013), which emphasizes an individual's ability and responsibility to perform self-care. The theory outlines a range of activities in which individuals engage to maintain health, enhance well-being, and improve quality of life. It also encourages active patient participation in the self-care process (Radwan et al., 2020). Before the experiment, participants were selected from diabetic patients attending the chronic disease clinic at the primary healthcare unit in Thap Sadet sub-district. All participants were screened and assessed according to the inclusion criteria. Those who met the criteria were invited to participate and asked to provide informed consent. The researchers explained the study in detail and distributed consent forms, which participants signed before joining the program.

To ensure reliable and valid results, all nine village health volunteers (VHVs) received thorough training before the study. The training program focused on the standardized procedures for administering the herbal foot bath, methods of data collection, and participant management. This training was a collaborative effort designed to ensure consistent understanding and implementation among the volunteers, making them an integral part of the broader initiative (Kowitt et al., 2015). Each VHV was assigned responsibility for eight participants, and the researchers regularly monitored their activities to ensure adherence to the study protocol. In addition, weekly meetings were held to review progress, address challenges, and provide ongoing guidance. The researchers also conducted frequent visits to each VHV's designated area to verify proper implementation of the intervention and offer feedback. This rigorous oversight helped ensure that all VHVs maintained high standards throughout the study.

The herbal foot bath mixture was carefully prepared using a combination of Plai rhizome, tamarind leaves, kaffir lime peel, turmeric rhizome, and lemongrass. Each of these ingredients has demonstrated a favorable safety profile in previous studies (Raksamat & Thongon, 2020; Fu et al., 2020; Wang et al., 2019; Siripongdumrongkul et al., 2020), supporting their safe use in topical applications. The herbal foot bath was prepared following a standardized protocol to ensure consistency across all intervention sessions. The formulation consisted of five key herbs—plai rhizome, tamarind leaves, kaffir lime peel, turmeric rhizome, and lemongrass—each precisely measured at 220 g. The herbs were boiled in 1,200 Liters of water at 80°C for 15 min to extract the active compounds, then cooled to a tolerable temperature before use. Each batch was prepared under controlled conditions, and the same formulation was used throughout the study to maintain consistency and reproducibility. Standardizing the herbal preparation ensured the reliability of the study outcomes and enhanced the potential for replication in future research. The fixed concentration of herbs and consistent preparation methods were strictly maintained throughout the intervention to minimize variability.

The method for preparing the herbal foot bath can be described as follows: 1) preparation of the herbs using 220 g of fresh herbs, including plai rhizome, tamarind leaves, kaffir lime peel, turmeric rhizome, and lemongrass, cutting them into small pieces and place them in a pot with 1,200 mL of water. Heat and boil the mixture for 15 min to extract

the herbs' properties into the water, 2) Addition of additional ingredients after straining the herbal residue from the boiling water, adding 15 g of camphor and 15 g of salt, and mix well with the herbal water, 3) preparation of a soaking basin using 2,000 mL of plain water at room temperature, pouring the herbal infusion into the basin, ensuring the water temperature for soaking is approximately 40°C, measuring the temperature by touching the water with your hand, 4) soaking the feet for 15 min. after soaking, cleaning the feet with a clean cloth, drying them thoroughly, especially between the toes, to prevent foot ulcers and unpleasant odors, 5) drying the herbal residue and storing it in the refrigerator for future use. This method ensures that the foot soak is prepared and used effectively, with proper attention to temperature and hygiene.

Preparing and managing the herbal foot bath was crucial, and the VHVs played a pivotal role in this process. Nine VHVs were assigned, each responsible for eight participants, ensuring a manageable ratio for effective oversight. The VHVs distributed the herbal foot bath mixture to participants every Monday during the experimental phase and every Tuesday during the three-month follow-up period. Additionally, each VHV maintained a logbook to record participants' foot bath sessions. They visited participants' homes to ensure proper documentation and adherence to the schedule. During each visit, the VHV provided guidance and explained the correct foot bath procedure. They ensured that participants followed the prescribed soaking duration and method, and monitored participants' compliance throughout the three-month follow-up period to maintain consistency and effectiveness.

A manual was created to demonstrate the steps for preparing the herbal foot bath and the correct procedure, including instructions for self-preparation and soaking. Each set of herbal ingredients was used for three soaks. Users were instructed to reheat the herbal mixture using the same method as the initial preparation, adding 15 g of salt and 15 g of camphor to the herbal water each time. After each use, the herbal residue should be dried and stored in the refrigerator. Detailed information about the herbal components used in the foot bath (Preecha et al., 2022) is provided in Table 1.

The intervention period lasted one month, followed by a three-month follow-up. This timeframe was selected based on previous research evaluating similar interventions for diabetic neuropathy. The one-month intervention allowed for the observation of the immediate effects of the herbal foot bath, while the three-month follow-up period was sufficient to assess the sustainability and long-term outcomes of the treatment. Studies by Huang et al. (2024) and Song et al. (2023) have demonstrated that these timeframes are effective for monitoring the impacts of diabetes-related treatments and interventions. To account for potential temperature-related effects, all foot baths in the intervention group were maintained at a consistent temperature of 40±2°C. The intervention consisted of 12 sessions over four weeks to assess the lasting effects beyond immediate thermal stimulation. This design enabled the researchers to isolate the effects of the herbal components from those attributed to temperature alone.

Table 1. Herb details for foot baths are categorized by properties and the amount used

Herb name	Properties	Weight (g)
Plai rhizome	Relieves muscle pain, reduces bruising and swelling, and treats sprains and strains.	80
Tamarind leaves	Enhances the skin's resistance to infections and cleanses impurities.	50
Kaffir lime peel	Provides a pleasant fragrance, moisturizes skin, helps with foot odor, and has antifungal properties.	30
Lemongrass	Relieves pain, reduces soreness, treats sprains and strains, has antifungal effects, and treats skin conditions.	30
Turmeric rhizome	Treats athletes' feet, ringworms, and other skin conditions, heals wounds, relieves pain and inflammation, and reduces swelling.	30
Salt	Eliminates foot odor, kills bacteria on the feet, and softens the skin on the soles.	15
Camphor	Treats chronic skin conditions, relieves itching, and treats ringworm and rashes.	15

For the duration of the trial, participants soaked their feet in herbal water for four weeks, with sessions held three times a week (Monday, Wednesday, and Friday), totaling twelve sessions. The 1st and 12th sessions were conducted at the Thap Sadet Sub-district Health Promoting Hospital, while the 2nd through 11th sessions took place at the participants' homes. The details of the program are provided in Table 2. The follow-up period lasted three months. The experimental group washed their feet in herbs once a week, on Wednesdays, for a total of twelve times. VHV, delivered the prepared herbs to the sample group every Tuesday. After three months, the researcher conducted post-experiment evaluations using a general interview form, the monofilament test, and the VAS test.

The control group received standard care as per the clinical guidelines for diabetic patients, which included routine medical check-ups, blood sugar monitoring, and general foot care advice provided by healthcare professionals. In addition to standard care, participants in the control group were given a self-care foot manual containing detailed instructions on proper foot hygiene, daily foot inspection techniques, and recommended exercises, as well as guidance on preventing foot complications related to diabetes.

Table 2. Details of herbal foot baths for reducing foot paresthesia in diabetic patients

Session	Activity details
1	**Knowledge promotion and interaction activity** 1) The researchers explained the objectives, research methods, measurements, evaluations, and details of the herbs used in the foot bath program. 2) The researchers conducted the pre-test evaluation at baseline through general interviews form, Monofilament test, VAS test. 3) The researchers educated the samples diabetes, body maintenance, and avoiding damage to the foot using slide presentations. 4) The researchers demonstrated the steps for preparing herbal foot bath and soaking feet in the herbal solution. The researcher provided the participants to soak their feet in herbs for the first time.
2–11	**Self-administered foot soak at home** 1) Participants soak their feet at home using 250 g of herbs in 2000 mL of water at a temperature of approximately 40°C. Participants perform foot exercises, including 15 repetitions of toe lifts and 15 rotations of the foot outward. The herbal solution can be used for 3 sessions within the same week.
12	**Group discussion and experiment conclusion** 1) The researcher conducted the final herbal foot bath session for the samples. 2) A group discussion were held to summarize the experiment, listen to feedback, and address any challenges faced during the herbal foot bath program.

2.4 Instruments of the study

The instruments utilized in this research were developed based on a comprehensive literature review and related research (Punjani, 2013; Radwan et al., 2020). The standard test for foot paresthesia in diabetic patients with complications was applied as follows:

Part 1: The general interview form: This tool was created by the researcher to measure general characteristics. The questionnaire consisted of 10 questions in both open-ended and closed-ended formats, including gender, age, marital status, education level, and occupation, as well as duration of diabetes, diabetes treatment, accident history, foot abnormalities, and foot ulcers.

Part 2: Monofilament test record form: The researcher created this record form to document the number of points with numbness in the foot by using the 10 g. Monofilament (Wang et al., 2017). The test evaluated sensation at four points on each foot, with the following four levels: Level 0 (normal sensation): The patient can feel the Monofilament at all four points on each foot, indicating normal sensation with no loss. Level 1 (mild sensory loss): The patient cannot feel the monofilament at any of the four points on each foot, indicating a slight sensation loss. Level 2 (moderate sensory loss): The patient cannot feel the Monofilament at 2–3 of the four points on each foot, indicating moderate sensation loss. Level 3 (severe sensory loss): The patient cannot feel the monofilament at any of the four points on each foot, indicating severe loss of sensation, which increases the risk of foot injuries without the patient noticing.

Part 3: VAS test: This test was developed by Hayes and Patterson (1921) and modified by Thanomsiang (2017). This tool was designed for linear measurement using a 5-centimeter-long rating scale to measure the severity of foot numbness as perceived by the patient. The scale consisted of a horizontal line where the far-left end represented the highest level of numbness (severe numbness) and the far-right end represented no numbness (no numbness).

The validity of the tool was assessed by three experts in public health, nursing, and traditional Thai medicine using the index of item-objective congruence (IOC). The IOC values ranged from 0.90 to 1.00. The reliability of the tool was tested with a tryout involving 30 diabetic patients with complications, similar to the study sample, but not included in the study. Data were analyzed for reliability, and a Cronbach's alpha coefficient of 0.90 was obtained for the VAS.

2.5 Data collection method

The researcher obtained permission from the local health authorities to conduct the study. After receiving permission, participants were recruited through chronic disease clinics, following the inclusion criteria. Once eligible participants were identified, informed consent was obtained. The participants were then given a consent form for the research to sign. The researcher conducted a four-week herbal foot bath program and used it for a three-month follow-up. The control group received standard care and a self-care foot manual. Both groups were assessed twice: at baseline and after the three-month follow-up.

2.6 Data analysis

Data analysis used descriptive statistics, including minimum-maximum, frequency, percentage, mean, and standard deviation (S.D.). The Kolmogorov-Smirnov test was applied to assess whether the dependent variables followed a normal distribution (goodness of fit). The results indicated that the dependent variables, including the VAS (p=0.334) and the number of numbness points (Monofilament) (p=0.263), were normally distributed (p>0.05). Either the Chi-square test or Fisher's exact test was used to evaluate the baseline characteristics between the intervention and control groups before the experiment. Moreover, foot numbness levels were compared between the intervention and control groups using the Chi-square test or Fisher's exact test for categorical variables. A p>0.05 was considered indicative of no significant difference between the groups at baseline. The paired t-test was applied to test the differences in mean values within the groups. Additionally, an independent t-test was used to compare mean differences between the intervention and control groups at baseline and after the three-month follow-up. The decision not to measure mean values immediately after the four-week herbal foot bath program was based on the study's objective to assess sustained effects rather than short-term changes. The three-month follow-up period allowed for evaluation of the long-term impact of the intervention.

2.7 Ethical consideration

The human research component of this study was approved by the Research Ethics Committee on Human Research at Valaya Alongkorn Rajabhat University under the Royal Patronage in Pathum Thani province. The project was assigned the identification numbers REC No. 0081/2023 and COA No. 0009/2024, and it received certification on January 31, 2024. The study was conducted under the Declaration of Helsinki. The participants were required to sign consent forms before participating in the research project. They were informed of the necessary confidentiality and data collection procedures.

3. RESULTS

3.1 Baseline characteristics

Table 3 demonstrates that baseline parameters were comparable between the intervention and control groups, indicating that the baseline characteristics were similar across both groups (p>0.05). The baseline characteristics revealed that the majority of participants were under 60 years old, with a mean age of 58.9 years (S.D. = 6.57), and a higher proportion were female (79.2%). Most participants were married (66.7%), had completed lower secondary school (86.1%), and worked as agriculturists (81.9%). Health-related characteristics showed that most individuals had been diagnosed with diabetes for 6–10 years (36.2%), with a mean duration of 10.7 years (S.D. = 8.00). The majority were consistent with their treatment (88.9%) and reported no history of accidents (90.3%). Additionally, most participants exhibited no foot abnormalities (88.9%) or foot ulcers (91.1%).

3.2 Level of number of points with numbness in the foot by monofilament test

Table 4 shows that, at baseline, most participants in the intervention group had mild sensory loss in the left foot (80.6%). By the three-month follow-up, a majority (72.2%) had experienced changes in the number of numbness points in the left foot. In the control group, most participants also reported mild sensory loss in the left foot at both baseline and follow-up (66.7% and 55.6%, respectively). Similarly, 55.6% of the intervention group had mild sensory loss in the right foot at baseline. At the three-month follow-up, 69.4% showed changes in numbness points. In contrast, the control group reported mild sensory loss in the right foot at both time points (69.4% at baseline and 58.3% at follow-up). There were no statistically significant differences between the intervention and control groups in baseline numbness levels of the left and right foot, as assessed by the Monofilament test (p>0.05), indicating comparable groups before the intervention. However, at the three-month follow-up, statistically significant differences were observed between the groups in numbness levels for both the left and right feet (p<0.001).

Table 3. Baseline characteristics data of the intervention and control group (n = 72)

Variables	Total n (%)	Intervention group n (%)	Control group n (%)	p-value
Gender				
Female	57 (79.2)	31 (86.1)	26 (72.2)	0.147[a]
Male	15 (20.8)	5 (13.9)	10 (27.8)	
Age (years)				
< 60	46 (63.9)	22 (61.1)	24 (66.7)	0.624[a]
≥ 60	26 (36.1)	14 (38.9)	12 (33.3)	
Marital status				
Single	14 (19.4)	7 (19.4)	7 (19.4)	0.785[a]
Married	48 (66.7)	23 (63.9)	25 (69.5)	
Widowed/divorced/separated	10 (13.9)	6 (16.7)	4 (11.1)	
Educational level				
Lower secondary school	62 (86.1)	33 (91.7)	29 (80.6)	0.173[a]
Secondary school or higher	10 (13.9)	3 (8.3)	7 (19.4)	
Occupational				
Agriculturist	59 (81.9)	28 (77.8)	31 (86.1)	0.358[a]
Merchant	13 (18.1)	8 (22.2)	5 (13.9)	
Duration of diabetes				
≤ 5 years	23 (31.9)	14 (38.9)	9 (25.0)	0.442[a]
6–10 years	26 (36.2)	12 (33.3)	14 (38.9)	
>10 years	23 (31.9)	10 (27.8)	13 (36.1)	
Diabetes treatment				
Consistent	64 (88.9)	30 (83.3)	34 (94.4)	0.260[b]
Inconsistent	8 (11.1)	6 (16.7)	2 (5.6)	
Accident history				
Yes	7 (9.7)	2 (5.6)	5 (13.9)	0.429[b]
No	65 (90.3)	34 (94.4)	31 (86.1)	
Foot abnormalities				
Yes	8 (11.1)	2 (5.6)	6 (16.7)	0.260[b]
No	64 (88.9)	34 (94.4)	30 (83.3)	
Foot ulcers				
Yes	6 (8.3)	4 (11.1)	2 (5.6)	0.674[b]
No	66 (91.7)	32 (88.9)	34 (94.4)	

Note: [a]Chi-square test, [b]Fisher's exact test, Significant difference p<0.05

Table 4. Level of number of points with numbness in the foot by monofilament test (n = 72)

Outcome variables	Time	Level	Group		*p*-value
			Intervention n (%)	Control n (%)	
Points with numbness in the left foot	Baseline	Normal sensation	0 (0.0)	0 (0.0)	0.397[b]
		Mild sensory loss	29 (80.6)	24 (66.7)	
		Moderate sensory loss	6 (16.7)	11 (30.6)	
		Severe sensory loss	1 (2.8)	1 (2.8)	
	3-month follow-up	Normal sensation	26 (72.2)	10 (27.8)	<0.001[b]*
		Mild sensory loss	10 (27.8)	20 (55.6)	
		Moderate sensory loss	0 (0.0)	6 (16.7)	
		Severe sensory loss	0 (0.0)	0 (0.0)	
Points with numbness in the right foot	Baseline	Normal sensation	0 (0.0)	0 (0.0)	0.459[b]
		Mild sensory loss	20 (55.6)	25 (69.4)	
		Moderate sensory loss	15 (47.1)	10 (27.8)	
		Severe sensory loss	1 (2.8)	1 (2.8)	
	3-month follow-up	Normal sensation	25 (69.4)	6 (16.7)	<0.001[a]*
		Mild sensory loss	11 (30.6)	19 (53.8)	
		Moderate sensory loss	0 (0.0)	21 (30.6)	
		Severe sensory loss	0 (0.0)	0 (0.0)	

Note: [a]Chi-square test, [b]Fisher's exact test, Significant difference $p<0.05$

3.3 Complications in individual patients from the herbal foot bath program

The researchers closely monitored participants for any adverse effects or complications throughout the study. Although no significant complications were observed, two participants reported minor skin irritation. These cases were promptly managed by recommending a milder herbal solution, reducing the frequency of foot bath sessions, and providing topical hydrocortisone ointment for symptom relief. Both participants fully recovered within 3 to 5 days, and no further issues were reported for the remainder of the study.

3.4 Effects of the herbal foot bath program between groups

Table 5 shows that there were no significant differences at baseline between the intervention and control groups in the mean VAS scores for the left and right feet, or in the number of numbness points in both feet, as assessed by the monofilament test ($p>0.05$). Therefore, comparisons of the mean changes in these variables were conducted after the three-month follow-up. The results demonstrated a statistically significant reduction in VAS scores for both the left and right feet, as well as a decrease in the number of numbness points in both feet in the intervention group compared to the control group ($p<0.001$).

Table 5. Comparison of the mean between the intervention group and control group (n = 72)

Variables	Baseline (Mean ± S.D.)	3-month follow-up (Mean ± S.D.)	*p*-value (a)
VAS of the left foot			
Intervention group	4.08 ± 0.28	1.77 ± 0.64	<0.001*
Control group	4.11 ± 0.32	4.05 ± 0.41	0.160
p-value (b)	0.696	<0.001)	
VAS of the right foot			
Intervention group	4.28 ± 0.45	1.94 ± 0.63	<0.001*
Control group	4.33 ± 0.48	4.22 ± 0.59	0.103
p-value (b)	0.615	<0.001*	
Number of points with numbness in the left			
Intervention group	1.30 ± 0.71	0.27 ± 0.45	<0.001*
Control group	1.44 ± 0.73	0.94 ± 0.79	<0.001*
p-value (b)	0.417	<0.001*	
Number of points with numbness in the right			
Intervention group	1.61 ± 0.80	0.30 ± 0.47	<0.001*
Control group	1.32 ± 0.81	1.16 ± 0.88	0.059
p-value (b)	0.467	<0.001*	

Note: Paired t-tests were used to assess the data within each group (*p*-value (a)), and independent t-tests were used between groups (*p*-value (b)). * Statistically significant at $p<0.05$

3.5 Effects of the herbal foot bath program within the group

When comparing parameters within the intervention group between baseline and the three-month follow-up, statistically significant reductions were observed in VAS scores for both the left and right feet, as well as in the number of numbness points in both feet as assessed by the monofilament test (p<0.001). In the control group, a statistically significant reduction in the number of numbness points was found in the left foot (p<0.001) and the right foot (p=0.039) between baseline and follow-up. However, there were no statistically significant changes in the mean VAS scores for either foot (Table 5).

4. DISCUSSION

As assessed by the VAS, the intervention group demonstrated reduced foot numbness scores for both the left and right feet. These findings are consistent with Honnonprai et al. (2020), who reported that participants using herbal treatments experienced a decrease in foot numbness after 4 and 12 weeks compared to the first week. This supports the notion that herbal foot care can effectively reduce numbness in diabetic patients. Similarly, Siripongdumrongkul et al. (2020) found that the use of herbal infusions combined with foot massage helped reduce the risk of foot ulcers. Raksamat and Thongon (2020) also demonstrated a statistically significant improvement in foot numbness symptoms, evaluated via the VAS, in both feet of diabetic patients. In addition, Fu et al. (2020) reported that traditional Chinese medicine foot baths were effective in alleviating symptoms of diabetic peripheral neuropathy. These consistent findings suggest that herbal foot bath programs are effective interventions for managing diabetic foot numbness. The improvements observed in both feet indicate the potential for widespread relief from paresthesia, a common and distressing complication in diabetic patients (Wang et al., 2019). The herbal foot bath likely works through multiple mechanisms, such as enhancing blood circulation, reducing inflammation, and soothing peripheral nerves. The herbal mixture used in this study consisted of plai rhizome, tamarind leaves, kaffir lime peel, turmeric rhizome, and lemongrass—each known for their unique therapeutic properties that contribute to reducing foot numbness (Kumar et al., 2021).

Turmeric rhizome and plai rhizome contain potent anti-inflammatory compounds such as curcumin, which have been shown to reduce inflammation (Ubonnuch et al., 2013). Since nerve inflammation is a common cause of paresthesia, these herbs can help alleviate nerve irritation and related symptoms. Additionally, lemongrass and kaffir lime peel are known to enhance blood circulation. Improved circulation promotes oxygen and nutrient delivery to nerve tissues, supporting nerve healing and reducing sensations of numbness (Siripongdumrongkul et al., 2020). Furthermore, camphor and plai rhizome possess analgesic properties that can help numb the nerves and provide pain relief, thereby reducing the discomfort associated with paresthesia. Tamarind leaves, another key ingredient in the herbal mixture, may also offer neuroprotective and soothing effects on nerve tissues (Preecha et al., 2022). Importantly, the combined effects of heat and herbal properties synergize to enhance therapeutic outcomes when these ingredients are used in a warm herbal foot bath. Warm water promotes vasodilation, allowing active herbal compounds to penetrate the skin more effectively and reach the underlying tissues (Honnonprai et al., 2020). This process can lead to decreased inflammation, improved circulation, and relief of nerve irritation, ultimately resulting in reduced pain, discomfort, and numbness, as reflected in lower VAS scores.

Therefore, the herbal foot bath can effectively reduce the number of numbness points in both feet, as assessed using the monofilament test. These findings align with the results of Preecha et al. (2022), who reported a significant reduction in abnormal sensation points in both feet following treatment. Similarly, Raksamat and Thongon (2020) observed a decrease in the number of numbness points in both feet using the same assessment method. This outcome suggests that the herbal ingredients used in the foot bath contribute to reducing sensory deficits. Lemongrass and kaffir lime peel are known to enhance oxygen circulation and improve the delivery of nutrients to nerve tissues in the feet, thereby helping restore sensation in previously numb areas (Thikekar et al., 2021; Ko et al., 2014). Additionally, turmeric and plai rhizomes have anti-inflammatory properties that may alleviate nerve compression and irritation, which in turn reduces areas with diminished sensation, as detected by the monofilament test. Tamarind leaves further support nerve repair and offer neuroprotection against further injury (Zamanifard et al., 2024; McGloin et al., 2021). In summary, the herbal foot bath contributes to the reduction of numbness in both feet by improving blood circulation, reducing inflammation, promoting nerve regeneration, and relieving muscle tension. These mechanisms likely explain the reduced number of numbness points observed during monofilament testing (Preecha et al., 2022; Raksamat & Thongon, 2020; Liu et al., 2018; Ruiz-Noa et al., 2021).

In summary, the findings indicate that the herbal foot bath significantly reduced foot paresthesia symptoms in diabetic patients, highlighting the effectiveness of non-pharmacological interventions in managing diabetic neuropathy. While previous studies have focused primarily on short-term outcomes immediately following interventions, this study extends the existing knowledge by demonstrating sustained improvements at the three-month follow-up. Furthermore, this research contributes to the literature by utilizing standardized assessment tools, including the VAS and the monofilament test, to objectively and quantitatively evaluate symptom reduction. These results underscore the therapeutic potential of herbal foot baths and support their integration into complementary care approaches for diabetic neuropathy.

The strengths of this study include its focus on diabetic patients with foot paresthesia, using reliable assessments like the VAS and monofilament test. The use of traditional herbal remedies adds cultural relevance, particularly in settings where traditional medicine is valued. The study showed a significant reduction in foot paresthesia after the three-month intervention. However, the short follow-up period raises uncertainty about the long-term sustainability of these improvements. Future research should include follow-ups at six months and one year to assess long-term effects. While the independent t-test provided accurate mean comparisons, an additional assessmen t immediately after the intervention could have revealed short-term effects.

This study has some limitations. First, the results apply only to individuals with characteristics similar to those of diabetic patients who have foot complications. Second, the lack of temperature control in the herbal foot bath, assessed by individual perception rather than a thermometer, may have affected outcomes. Third, the study was not blinded, so expectation bias could have influenced participants' perceptions of improvement. Fourth, the control group did not receive a placebo, making it unclear whether the observed effects were due to the herbal components or the thermal effects of the foot bath. Fifth, the short three-month follow-up period limits the ability to assess long-term efficacy. Future studies should include extended follow-up and a placebo group. Lastly, the study used specific local herbs, so its findings may not be applicable to other populations with different herbal traditions or environmental conditions.

5. CONCLUSION

The herbal foot bath program significantly reduced foot paresthesia in diabetic patients, as indicated by lower VAS scores and fewer numbness points on the monofilament test. This suggests improved neuropathic symptoms, mobility, and quality of life. The herbal foot bath should be integrated into primary care, especially in community health programs. Healthcare providers and VHVs should support diabetic patients with neuropathy through awareness, self-care education, and regular check-ups. Policymakers should standardize herbal formulations and improve access to traditional Thai medicine, particularly in rural and border areas. Local governments should prioritize healthcare access in remote regions, including screening and foot care. Future research should assess the long-term benefits, sustainability, and cost-effectiveness of herbal foot baths, comparing them to other treatments and incorporating patient-centered outcomes like quality of life and satisfaction.

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