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Effect of swimming exercise program on quality of life in patients with diabetic foot ulcer

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Abstract: This research aimed to examine the effect of a swimming exercise program on the quality of life in patients with diabetic foot ulcers (DFUs). DFUs are a common complication of diabetes that significantly impact patients' physical and psychological well-being and impose a substantial burden on healthcare systems. Physical activity, including swimming, has been shown to improve various aspects of health and well-being. However, its specific effects on the quality of life in patients with DFUs have not been extensively studied. The study included twenty patients diagnosed with DFUs who volunteered to participate in a 12-week swimming exercise program. The program consisted of three one-hour sessions per week, with exercises performed in an indoor swimming pool. Participants' quality of life was assessed using the Diabetic Foot Ulcer Scale Short Form (DFS-SF) before the program and at 4, 8, and 12 weeks into the program. The results demonstrated significant improvements in various domains of quality of life among participants. The leisure, physical health, dependence/daily life, negative emotions, worry about ulcers/feet, and bothered by ulcer care domains all showed positive changes, with reduced scores on negative items and increased scores on positive items over time. These findings highlight the potential benefits of swimming as a therapeutic intervention for improving the quality of life in patients with DFUs. Swimming, as a low-impact aerobic exercise, offers physiological and psychological advantages, including fat burning, mood improvement, stress reduction, and enhanced cognitive function. The study suggests that incorporating swimming exercise programs into the management and treatment of DFUs may lead to improved overall well-being and quality of life for these patients. Further research and larger-scale studies are necessary to validate these findings and explore the long-term effects of swimming exercise programs on the quality of life in patients with DFUs. Nevertheless, this research provides valuable insights for healthcare professionals in developing comprehensive treatment approaches for individuals with DFUs.

Keywords: *Aerobic exercise, Diabetic foot ulcer, Physical health improvement, Psychological benefits, Quality of life, Swimming exercise.*

1. Introduction

1.1. Diabetic Foot Ulcer (DFU)

Diabetic foot ulcer is one of the most common complications, which effects the patient's ability to move besides the effects on his/her psychological health, taking into consideration the high costs on the health care system, the direct costs of treating diabetic foot complications exceed the cost of treating many common cancers (Barshes et al., 2013).

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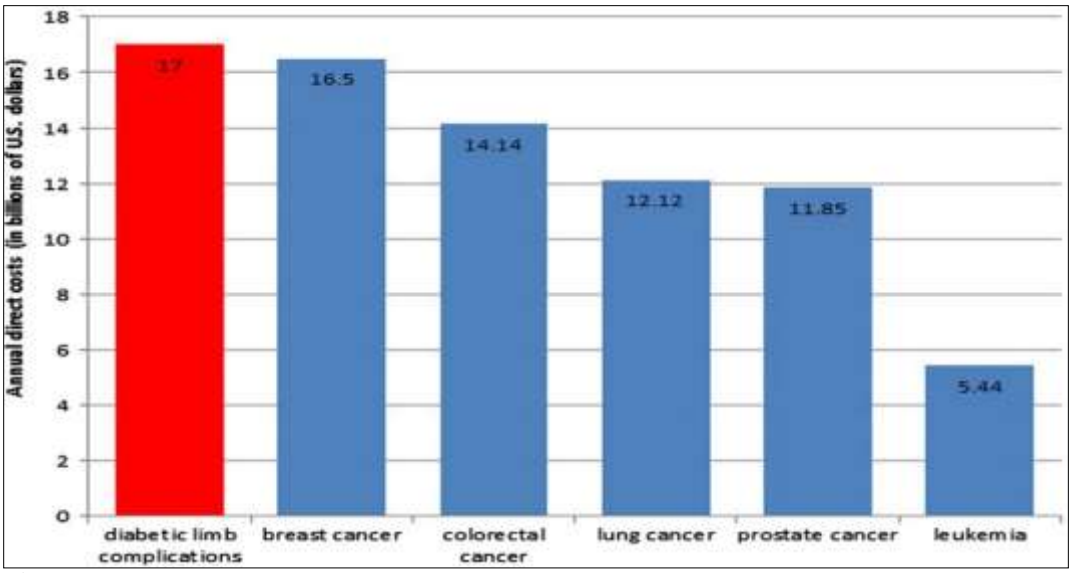

Figure 1.
The estimated annual direct costs of diabetic limb complications in comparison to the annual direct costs of the five most costly cancers in the United States.

A study of 785 million outpatient visits by people with diabetes in the United States between 2007 and 2013 suggested that DFU and associated infections constitute a powerful risk factor for visits to emergency departments and hospital admission (Skrepnek et al., 2017). However, even if there is no optimal cure for diabetes, we still can make life easier for those whom suffering by controlling the case and limit it is effects.

The need for physical activity such as walking, swimming, and carrying out daily physical activities such as housework that helps in reducing weight, spend energy, and reduce blood pressure in addition to improving the psychological and physiological state of the individual. Continuous physical activities are considered key points in improving the quality of life by increasing blood circulation, metabolism and other physiological functions (Schauer et al., 2020).

1.2. Sport Psychological and Physiological Benefits

Graff and Holderman (2001) stated that sport has psychological and physiological benefit like:

- Improve the ability of the individual to burn fat
- Improve mood and a sense of happiness
- Improve the external appearance of the individual
- Improve adaptation and frees him from anxiety and frustration
- Improve sleep process
- Provide enough time to reflect and think
- Improve metabolism in human body.

Aerobic training is one of the most important types of training, and Xing et al., (2018) defined aerobic training as that training that increases the heart rate by using large muscle groups for a certain amount of time. It includes exercises such as brisk walking, jogging, swimming, and cycling.

1.2.1. Swimming

Swimming is one of the aerobic exercises that can benefit health (Gallè et al., 2016). Swimming is one of the best types of physical activity that positively affects health. Physical activities are enjoyable and refreshing, and they are affordable. It is also considered one of the safest and most enjoyable forms

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of aerobic exercise (Denning et al., 2012).Swimming is a low-impact exercise that has many mental and physical health benefits while being a good leisure activity.

Swimming is considered a type of therapy, especially for the elderly, when they practice it with intensity appropriate for their age, as it burns a lot of calories, strengthens their musculoskeletal system and other physiological functions, and have little negative impacts on their joints, and other organs (Torres-Ronda & i del Alcázar, 2014). Furthermore, moderate-intensity aerobic activities are potential lifestyle therapies for improving cognitive function in adults with mild cognitive impairment who are at a higher risk of dementia. In a study by Song & Doris (2019) on some cognitive function and quality of life for Alzheimer's disease for 120 participants, it was found that the group who practiced a moderate-intensity aerobic exercise program showed a significant improvement in mental abilities and health-related quality of life.

1.2.2. The Benefits of Swimming in Removing Stress

Bringing joy to the individual helps reduce life stress, and swimming reduces blood pressure. Swimming is practiced by a wide range of people, varying in age, health, and hygienic standards, not only as a sport, but also for recreational and educational use and rehabilitation therapy (Kamioka et al., 2010). Swimming is also considered a meditation sport, which means that there is an increase in blood flow to the brain, allowing the individual to assess stressors more calmly. This leads to lower levels of stress, depression, and anxiety while swimming (Atkinson, 2016).

1.2.3. Quality of Life

The DFUs have a great effect on patients' lives. Not only financially, but also because the movement restrictions caused by the anatomy of the foot require a new way of life (Goodridge et al., 2005). In addition, Ribu and Wahl (2004) mentioned DFUs not only affects physical health, but also has psychological and emotional effects. In other words, DFUs have a variety of effects on patients' quality of life (QoL).

1.2.4. Materials and Methods

A permission letter will be prepared and submitted to Al-IMAN Hospital in Jordan. The researcher will meet with the hospital director and other staff to request their assistance, and explain the purpose of the research and the mechanism involved.

Setting**:**

The patient will be educated on wound care, nutrition, management of the ulcer, Foot exercises and measurements will be applied in the hospital environment, while the swimming program will be shifted to a separate building outside the hospital environment. The separate building contains office space for program staff, and an indoor swimming pool of twenty-five meters in length and 10 meters in width, bathrooms and changing rooms.

1.2.5. Participants

The sample will consist of twenty patients with age 50 ± 5.5 years, diagnosed with DFUs from the AL Iman hospital will included in the current study, So that patients coming to the hospital will be asked to volunteer for this study

1.2.6. Inclusion Criteria

This study includes patients with diabetic foot ulcer have superficial diabetic ulcer partial or full thickness (Wagner Classification, Grade 1) (Wagner, 1979).

1.2.7. Exclusion Criteria

Patients have another chronic disease such as (liver failure, congestive heart failure, end-stage renal disease, cancer), or use medication interact with healing like (cytotoxic drugs, glucocorticoids,

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immunosuppressive drugs). Patients who prefer treatment outside of experience, or desire to withdraw from any step of the study. Patients in other stages of Wagner's classification

1.2.8. Procedure

Participants will be allocated sixty-minute exercise sessions, three times a week for twelve weeks, at a pool temperature of 29°C to 33°C for the swim group. The benefits, potential risks, and negative effects of the sessions will be explained to participants in this study before participants sign informed consent forms. The tests will be conducted prior to the start of the current study and will be repeated after 4,8,12 weeks. Participants can stop sessions at any time they feel uncomfortable. Session instructions will be given to participants during the 12 weeks of this study by qualified physical education instructors.

Waterproof covers will protect the wound, the dressing will be applied 3 times weekly. Supervised exercise training will be performed for 1hr/day, 3 days/week at 40–60% heart rate reserve for 12 weeks.

1.2.9. Research Instruments

The tools used in this study will include the Wagner Ulcer Classification, exercise log, and the Diabetic Foot Ulcer Short Scale (DFS-SF).

1.2.10. Diabetic Foot Ulcer QOL Scale

This tool has internal accuracy, reliability, validity, and sensitivity when it comes to wound severity and healing. There are 58 elements in total, which are divided into 11 domains as follows: leisure, physical health, daily activities, emotions, non-compliance, family, friends, positive attitude, treatment, satisfaction, and financial, While Bann et al. (2003) mention that its abbreviated DFS-SF version contained a similar level of robustness and sensitivity. The Diabetic Foot Ulcer Scale Short Form (DFS-SF), which includes a total of 29 items (each on a 5-point Likert scale), consisting of six subscales: leisure (five items), dependence/daily life (five items), negative emotions (NEs) (six items), physical health (five items), worry about ulcers (WUC)/feet (four items), and burden from ulcer care (four items) (Bann et al., 2003). The researcher will distribute the questionnaire to patients before the start of the program, and after 4,8,12 weeks.

1.2.11. Swimming Exercise Log

Patients with DFUs in experimental group will be given instructions that include the following information:

i. Every training in the swimming pool will last for 50 minutes between 5 minutes warm up and 5 minutes cool down.
ii. The intensity of the training will be moderate and intermittent according to the pulse rate that we do not want higher (40-60% of the heart reserve).
iii. The exercises will take place in a 25-meter swimming pool. At the beginning of the training, a warm-up exercise will be performed for 5 minutes and 5 minutes cool down in the water, the remaining time the participants will swim on the chest and crawl.
iv. At first, short swimming distances (up to 25 metres) will be selected with breaks, which later will be increased to 50 meters with short rest periods.

1.2.12. Wagner Ulcer Classification

The ulcer condition will be categorized according to the Wagner Ulcer Classification System (Table 1).

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Table 1.
Wagner ulcer classification system.

Grade	Lesion
0	No open lesions; may have deformity or cellulitis
1	Superficial diabetic ulcer (Partial or full thickness)
2	Ulcer extension to ligament, tendon, joint capsule, or deep fascia without abscess or osteomyelitis
3	Deep ulcer with abscess, osteomyelitis, or joint sepsis
4	Gangrene localized to portion of forefoot or heel
5	Extensive gangrenous involvement of the entire foot

Wagner Grades used to identify the seriousness of the ulcer. The aim of the Wagner Grades is to help specialists to properly track and treat diabetic foot ulcers. This grading system classifies diabetic foot ulcers with numbers from zero to five (Mehraj & Shah, 2018).

2. Data Analysis

2.1. Statistical Analysis

Repeated Measures ANOVA It is use when multiple measures of the same variable are taken on the same or matched participants under different settings or over two or more time periods in a research design (Kraska & Salkind, 2010). The selected patients will be given the questionnaire. The details, the purpose of the study and the time required to complete the study will be explained. Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 25.0 (IBM SPSS® Software, USA), and the level of significance will be set at $p < 0.05$. Descriptive and Repeated measures ANOVA test was performed.

3. Results

3.1. Descriptive Data Analysis

The mean DFU areas were compared in this study. A significant difference was found according to swimming programme and foot exercises groups' between beginning mean DFU areas and the mean DFU areas in the 4th, 8th, and 12th weeks ($P<0.05$).

3.2. Descriptive Statistics

Table 2.

	Age (By year)		Body mass index (BMI)		DM length (By Year)	
Group	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation
Swimming program	49.7	3	31.76	3	10.7	2.3

3.2.1. Leisure

Table 3.
Means and standard deviation for Leisure subscales due to swimming programme group (n=15).

Items	Beginning		4th wk		8th wk		12th wk	
	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation
a) Stopped you from doing the hobbies and recreational	4.73	0.46	3.73	0.46	2.73	0.46	1.73	0.46

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activities that you enjoy								
b) Changed the kinds of hobbies and recreational activities that you enjoy doing	4.47	0.52	3.47	0.52	2.47	0.52	1.47	0.52
c) Stopped you from getting away for a holiday or a weekend break	4.80	0.41	3.80	0.41	2.80	0.41	1.80	0.41
d) Made you choose a different kind of holiday or short break than you would have preferred	4.73	0.59	3.80	0.41	2.80	0.41	1.80	0.41
e) Meant that you had to spend more time planning and organising for leisure activities	4.93	0.26	3.93	0.26	2.93	0.26	1.93	0.26
Total leisure	4.73	0.33	3.75	0.31	2.75	0.31	1.75	0.31

Table 3 shows that according to swimming programme group, the means of Leisure subscale remarkably increased by decreasing the means of negative items in Leisure subscale, in all 3 follow-ups compared to the Beginning findings.

3.2.2. Physical Health

Table 4.
Means and standard deviation for Physical health subscales due to swimming programme Group (n=15).

Items	**Beginning**		**4th wk**		**8th wk**		**12th wk**	
	Mean	**Std. deviation**	**Mean**	**Std. deviation**	**Mean**	**Std. deviation**	**Mean**	**Std. deviation**
a) Fatigued or tired	4.80	0.56	3.87	0.35	2.87	0.35	1.87	0.35
b) Drained	4.80	0.41	3.80	0.41	2.80	0.41	1.80	0.41
c) That you had difficulty sleeping	4.80	0.41	3.80	0.41	2.80	0.41	1.80	0.41
d) Pain while walking or standing	4.87	0.35	3.87	0.35	2.87	0.35	1.87	0.35
e) Pain during the night	4.87	0.35	3.87	0.35	2.87	0.35	1.87	0.35
Total Physical health	4.83	0.37	3.84	0.34	2.84	0.34	1.84	0.34

Table 4 shows that according to swimming programme group, the means of Physical health subscale remarkably increased by decreasing the means of negative items in Physical health subscale, in all 3 follow-ups compared to the Beginning findings.

3.2.3. Dependence/Daily Life

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Table 5.
Means and standard deviation for Physical health subscales due to swimming programme Group (n=15).

Items	Beginning		4th wk		8th wk		12th wk	
	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation
a) Had to depend on others to help you look after yourself (such as washing and dressing yourself)	4.87	0.35	3.87	0.35	2.87	0.35	1.87	0.35
b) Had to depend on others to do household chores such as cooking, cleaning or laundry	4.80	0.41	3.80	0.41	2.80	0.41	1.80	0.41
c) Had to depend on others to get out of the house	4.73	0.59	3.80	0.41	2.80	0.41	1.80	0.41
d) Had to spend more time planning or organising your daily life	4.87	0.35	3.87	0.35	2.87	0.35	1.87	0.35
e) Felt that doing anything took longer than you would have liked	4.20	0.56	3.27	0.46	2.27	0.46	1.27	0.46
Total Physical health	4.69	0.37	3.72	0.33	2.72	0.33	1.72	0.33

Table 5 shows that according to swimming programme group, the means of Physical health subscale remarkably increased by decreasing the means of negative items in Physical health subscale, in all 3 follow-ups compared to the Beginning findings.

3.2.4. Negative Emotions

Table 6.
Means and standard deviation for Negative emotions subscales due to swimming programme Group (n=15).

Items	Beginning		4th wk		8th wk		12th wk	
	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation
a) Angry because you were not able to do what you wanted to do	4.47	0.52	3.47	0.52	2.47	0.52	1.47	0.52
b) Frustrated by others doing things for you when you would rather do things yourself	4.87	0.35	3.87	0.35	2.87	0.35	1.87	0.35
c) Frustrated because you were not able to do what you wanted to do	4.93	0.26	3.93	0.26	2.93	0.26	1.93	0.26
d) Worried that your ulcer(s) will never heal	4.93	0.26	3.93	0.26	2.93	0.26	1.93	0.26
e) Worried that you may have to have an amputation	4.93	0.26	3.93	0.26	2.93	0.26	1.93	0.26

f) Worried about injury to your feet	4.93	0.26	3.93	0.26	2.93	0.26	1.93	0.26
Total Negative emotions	4.84	0.21	3.84	0.21	2.84	0.21	1.84	0.21

Table 6 shows that according to swimming programme group, the means of Negative emotions subscale remarkably increased by decreasing the means of negative items in Negative emotions subscale, in all 3 follow-ups compared to the Beginning findings.

3.2.5. Worried About Ulcers/Feet

Table 7.
Means and standard deviation for Worried about ulcers/feet subscales due to swimming programme Group (n=15).

Items	Beginning		4th wk		8th wk		12th wk	
	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation
a) Depressed because you were not able to do what you wanted to do	5.00	0.00	4.00	0.00	3.00	0.00	2.00	0.00
b) Worried about getting ulcers in the future	5.00	0.00	4.00	0.00	3.00	0.00	2.00	0.00
c) Angry that this has happened to you	5.00	0.00	4.00	0.00	3.00	0.00	2.00	0.00
d) Frustrated because you have difficulty in getting about	4.93	0.26	3.93	0.26	2.93	0.26	1.93	0.26
Total Worried about ulcers/feet	4.98	0.06	3.98	0.06	2.98	0.06	1.98	0.06

Table 7 shows that according to swimming programme group, the means of Worried about ulcers/feet subscale remarkably increased by decreasing the means of negative items in Worried about ulcers/feet subscale, in all 3 follow-ups compared to the Beginning findings.

3.2.6. Bothered by Ulcer Care

Table 8.
Means and standard deviation for Bothered by ulcer care subscales due to swimming programme Group (n=15).

Items	Beginning		4th wk		8th wk		12th wk	
	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation
a) Having to keep the weight off your foot ulcer	4.47	0.64	3.53	0.52	2.53	0.52	1.53	0.52
b) The amount of time involved in caring for your foot ulcer (including dressing changes, waiting for the district nurse and	4.47	0.52	3.47	0.52	2.47	0.52	1.47	0.52

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keeping the ulcer clean)								
c) The appearance, odour or leaking of your ulcer	4.60	0.63	3.67	0.49	2.67	0.49	1.67	0.49
d) Having to depend on others to help you care for your foot ulcer	4.33	1.05	3.40	0.83	2.47	0.64	1.53	0.52
Total Bothered by ulcer care	4.47	0.46	3.52	0.41	2.53	0.40	1.55	0.40

Table 8 shows that according to swimming programme group, the means of Bothered by ulcer care subscale remarkably increased by decreasing the means of negative items in Bothered by ulcer care subscale, in all 3 follow-ups compared to the Beginning findings.

Repeated measures ANOVA for swimming programme Group

Table 9.
Means and standard deviation for DFS-SF Quality Of Life subscales due to swimming programme Group (n=15).

Domain	Beginning		4th wk		8th wk		12th wk		F	Sig.
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation		
Leisure	4.73	0.33	3.75	0.31	2.75	0.31	1.75	0.31	1631.086	0.000
Physical health	4.83	0.37	3.84	0.34	2.84	0.34	1.84	0.34	1389.738	0.000
Dependence/Daily life	4.69	0.37	3.72	0.33	2.72	0.33	1.72	0.33	1374.698	0.000
Negative emotions	4.84	0.21	3.84	0.21	2.84	0.21	1.84	0.21	3687.250	0.000
Worried about ulcers/Feet	4.98	0.06	3.98	0.06	2.98	0.06	1.98	0.06	43681.000	0.000
Bothered by ulcer care	4.47	0.46	3.52	0.41	2.53	0.40	1.55	0.40	816.837	0.000
Total Form	4.76	0.24	3.78	0.22	2.78	0.22	1.78	0.23	3107.959	0.000

Table 9 shows that according to swimming programme group, the means of total quality of life remarkably increased by decreasing the means of negative items in form, in all 3 follow-ups compared to the Beginning findings.

4. Discussion

The research study aimed to investigate the effect of a swimming exercise program on the quality of life in patients with diabetic foot ulcers (DFUs). DFUs are a common complication of diabetes that not only affects physical health but also has psychological and emotional effects, significantly impacting the quality of life of individuals. The high costs associated with treating DFUs further emphasize the need for effective interventions to improve patients' lives.

The study highlighted the potential benefits of physical activity, including swimming, in managing diabetes and its complications. Swimming, as an aerobic exercise, offers numerous physiological and psychological advantages. It helps burn fat, improves mood, enhances physical appearance, reduces anxiety and frustration, improves sleep, and boosts metabolism. These benefits are particularly relevant for individuals with DFUs, as they often experience limitations in mobility and have a higher risk of psychological distress.

The choice of swimming as the exercise program in this study is significant. Swimming is a low-impact exercise that provides mental and physical health benefits while being a safe and enjoyable form of aerobic exercise. It offers therapeutic advantages, especially for older adults, by burning calories,

strengthening the musculoskeletal system, and improving various physiological functions without putting excessive stress on joints and other organs.

Moreover, the study emphasized the potential of swimming as a lifestyle therapy for improving cognitive function and overall quality of life. Cognitive impairment and the risk of dementia are common concerns in individuals with diabetes, and moderate-intensity aerobic activities, such as swimming, have shown positive effects in enhancing mental abilities and health-related quality of life.

Swimming also has stress-reducing properties, bringing joy and reducing blood pressure. It can be considered a form of meditation sport that increases blood flow to the brain, allowing individuals to better manage stressors and experience lower levels of stress, depression, and anxiety while swimming.

The research design involved a 12-week swimming exercise program, three times a week, for patients with DFUs. The study used various research instruments, including the Wagner Ulcer Classification system to assess the severity of ulcers, exercise logs to track training sessions, and the Diabetic Foot Ulcer Short Scale (DFS-SF) to measure the quality of life in different domains. The data were analyzed using repeated measures ANOVA to examine the changes over time.

The results of the study indicated significant improvements in the quality of life of patients with DFUs who participated in the swimming exercise program. The domains of leisure, physical health, dependence/daily life, negative emotions, worry about ulcers/feet, and bothered by ulcer care all showed positive changes, with decreased scores on negative items and increased scores on positive items. These findings demonstrate the effectiveness of swimming as an intervention to enhance the overall well-being and quality of life in patients with DFUs.

In conclusion, the study highlights the potential benefits of a swimming exercise program in improving the quality of life of patients with diabetic foot ulcers. Swimming, as a low-impact aerobic exercise, offers physiological and psychological advantages that positively impact physical health, mood, cognitive function, and stress levels. The findings of this research provide valuable insights for healthcare professionals and emphasize the importance of incorporating physical activity, such as swimming, into the management and treatment of DFUs. Further research and larger-scale studies are warranted to confirm these findings and explore the long-term effects of swimming exercise programs on the quality of life in patients with DFUs.

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