HYDROTHERAPY FOR GLYCEMIC CONTROL AND ANKLE BRACHIAL INDEX IN PATIENTS WITH TYPE 2 DIABETES MELLITUS: A LITERATURE REVIEW

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Abstract

Diabetes mellitus is a world health problem that needs continuous treatment. Hydrotherapy is a non-pharmacological therapy that can reduce blood sugar levels and increase the ankle brachial index in patients with type 2 diabetes mellitus. The aim of this study was to determine the effect of hydrotherapy on blood sugar levels and ankle brachial index in patients with type 2 diabetes mellitus. The design used was a literature review by using Google Scholar, Garuda, PubMed, and Science Direct databases. Article search using boolean operators. "OR" "AND". The inclusion criteria are article publications from 2019-2025 with full text, Indonesian and English, RCT, pra-experimental, quasi experimental, case study. The results of this study were 14 articles stating hydrotherapy could lower blood glucose levels and 9 articles stating hydrotherapy could increase ankle brachial index. The conclusion of this study is that hydrotherapy can reduce blood glucose levels and increase the value of the ankle brachial index.

Keywords: Ankle Brachial Index; Blood Sugar; Diabetes Mellitus; Hydrotherapy

1. INTRODUCTION

Diabetes is a highly prevalent disease and is considered one of the most important non-communicable diseases (NCDs) in the Global Burden of Disease Study (Abbafati et al., 2020) Diabetes mellitus is a chronic health condition that requires continuous and comprehensive care (Elsayed et al., 2023). Type 2 diabetes mellitus (T2DM) is a metabolic disorder characterized by impaired insulin secretion by pancreatic β-cells and the inability of body cells to respond adequately to insulin (Galicia-Garcia et al., 2020; Roden & Shulman, 2019).

Diabetes has a substantial impact on human health. According to a report from the International Diabetes Federation, an estimated 537 million people are living with the condition.(International Diabetes Federation, 2021). According to the 2018 Basic Health Research (Riset Kesehatan Dasar), the prevalence of diabetes mellitus among Indonesians aged >15 years was estimated at 19, 465, 100 people (Kementerian Kesehatan Republik Indonesia, 2018).

In 2019, diabetes was responsible for approximately 1.5 million deaths worldwide, with 48% of diabetes-related deaths occurring before the age of 70 years (World Health Organization, 2023). In Indonesia, the estimated number of diabetes-related deaths among individuals aged 20–79 years was 236,711 (International Diabetes Federation, 2021).

Hyperglycemia occurs when blood glucose levels become abnormally elevated. When blood glucose levels rise, the pancreas normally releases insulin to facilitate glucose uptake by cells and restore blood glucose levels to the normal range (Radheshyam et al., 2022). In people with diabetes, hyperglycemia may result from inadequate insulin synthesis or impaired insulin action (Elsayed et al., 2023). Diabetes mellitus increases the risk of various complications resulting from macrovascular and microvascular damage and can adversely affect several organs, including the brain, kidneys, heart, and eyes(Arnold et al., 2020; Berbudi et al., 2019; Tanase et al., 2020).

Poorly controlled diabetes mellitus may lead to various complications, including peripheral artery disease (PAD) (Hinchliffe et al., 2020). PAD is characterized by impaired blood flow to the lower or upper extremities due to narrowing or obstruction of the peripheral arteries, which may manifest as weakness or discomfort in the affected limbs (Bevan & White Solaru, 2020; Criqui et al., 2021). Peripheral circulation can be assessed using the Ankle-Brachial Index (ABI), a clinically useful measure for detecting peripheral arterial disease (Casey et al., 2019).

ABI is a non-invasive vascular assessment used to detect signs of peripheral arterial disease and evaluate lower-extremity perfusion (Tsai et al., 2021). ABI is calculated by dividing the systolic blood pressure measured at the ankle, using the dorsalis pedis or posterior tibial artery, by the systolic blood pressure measured at the arm, using the brachial artery (Abouhamda et al., 2019).

The management of diabetes mellitus includes both pharmacological and non-pharmacological interventions. Pharmacological therapy primarily involves the use of antihyperglycemic medications to control blood glucose levels (Kurniasari et al., 2023; Perkumpulan Endokrinologi Indonesia, 2021). Non-pharmacological interventions include physical exercise, dietary modification, herbal therapies, and hydrotherapy (Sutrisna et al., 2024).

Hydrotherapy is a therapeutic approach that utilizes water to promote, maintain, and restore health. Hydrotherapy encompasses various modalities, including drinking water, sauna therapy, bathing, steam baths, foot immersion, sitz baths, aquatic exercise, and the application of cold or warm water as compresses (Jazani et al., 2023; Warseno & Sukmawati, 2019). Hydrotherapy may provide several physiological benefits, including pain relief, reduction of muscle spasms, muscle relaxation, improved range of motion, enhanced blood circulation through vasodilation, and increased muscle strength (Setiawan et al., 2021).

In patients with diabetes mellitus, hydrotherapy may include adequate water intake and foot immersion therapy (Istiroha et al., 2022; Savitri & Ratnawati, 2022). Adequate water intake may support renal function and contribute to maintaining physiological fluid balance and metabolic processes, potentially helping to prevent elevated blood glucose levels (Saherna & Rezkiawan, 2020). Foot immersion therapy may improve peripheral blood circulation and stimulate sensory nerves in the feet. This stimulation may contribute to autonomic and physiological responses involving various organs, including the pancreas, which plays an important role in insulin production and blood glucose regulation (Damayanti et al., 2021).

Therefore, this literature review aimed to determine the effects of hydrotherapy on blood glucose levels and the Ankle-Brachial Index (ABI) in patients with type 2 diabetes mellitus.

2. METHODOLOGY

This study employed a literature review design. The Population, Intervention, Comparison, Outcome, and Time (PICOT) framework was used to organize the review and determine its focus. The components of the framework were as follows: P, patients with diabetes mellitus; I, hydrotherapy; C: none; O: blood glucose levels and the Ankle-Brachial Index (ABI); and T, studies published between 2019 and 2023. The research question was: “How does hydrotherapy reduce blood glucose levels and improve the Ankle-Brachial Index in patients with diabetes mellitus?”

The literature search was conducted in Indonesian through the Google Scholar and GARUDA databases from May to June 2025, using Boolean operators “OR” and “AND.” The following keywords were used: “pasien diabetes melitus” OR “diabetes melitus tipe 2” AND “hidroterapi” OR “minum air putih” OR “spa kaki diabetes” OR “rendam kaki” AND “penurunan kadar gula darah” OR “peningkatan nilai ankle brachial index.”

An additional literature search was conducted in English through Google Scholar, GARUDA, PubMed, and ScienceDirect from May to June 2025, using the Boolean operators “OR” and “AND.” The search keywords included “diabetes mellitus patients” OR “type 2 diabetes mellitus” AND “hydrotherapy” OR “drinking water” OR “diabetic foot spa” OR “foot immersion” AND “decreased blood glucose levels” OR “increased Ankle-Brachial Index values.”

The inclusion criteria comprised full-text articles published between 2019 and 2023 in Indonesian or English in national or international journals. Eligible study designs included randomized controlled

trials (RCTs), pre-experimental studies, quasi-experimental studies, and case studies. The exclusion criteria were review articles and articles retrieved from institutional repositories.

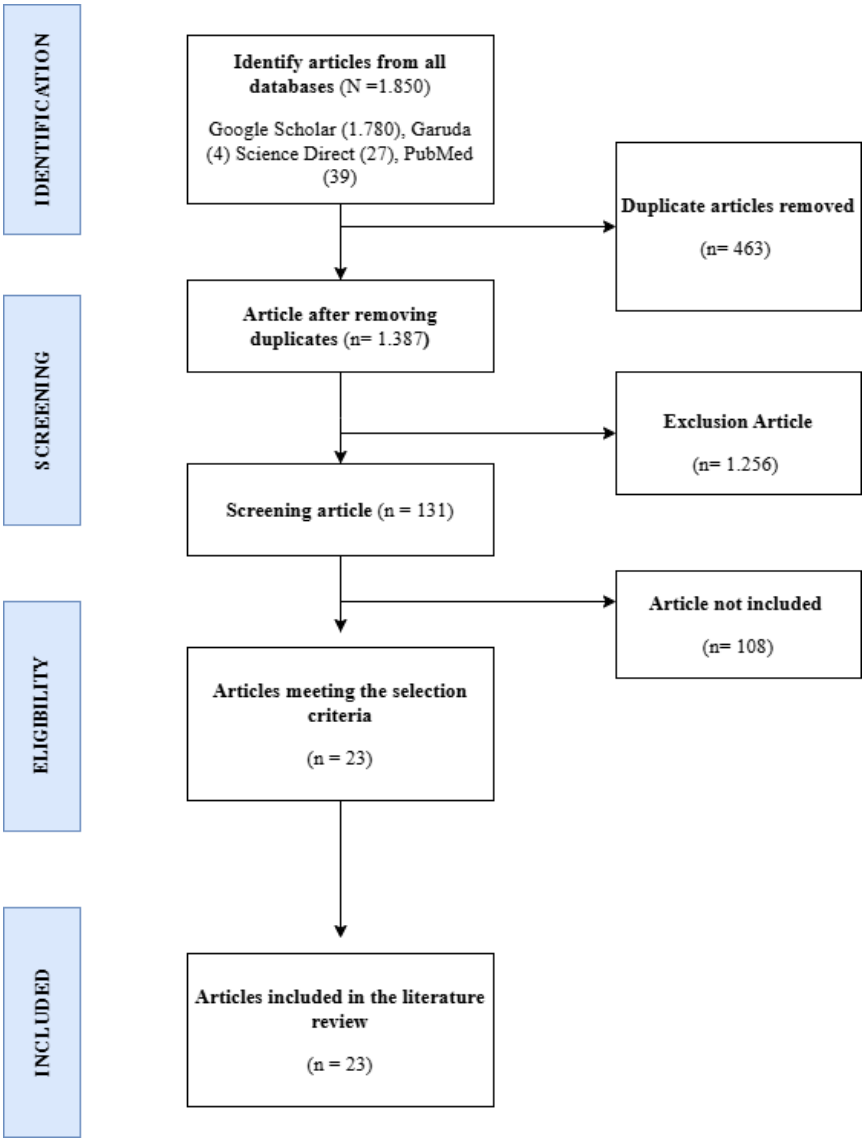


Figure 1. *PRISMA Flow Diagram of Literature Search and Selection*

3. RESULTS

The literature search identified 23 articles, comprising 14 articles on the effects of hydrotherapy on blood glucose levels in patients with type 2 diabetes mellitus (Table 1) and 9 articles on the effects of hydrotherapy on the Ankle-Brachial Index (ABI) in patients with type 2 diabetes mellitus (Table 2). The researchers subsequently screened the articles by reviewing their titles and abstracts according to the inclusion criteria. Ultimately, 23 articles were selected for analysis and categorized into two themes, as follows:

3.1 Effects of Hydrotherapy on Blood Glucose Levels in Patients with Type 2 Diabetes Mellitus

Table 1. Literature Search Results Based on Theme 1

No.	Author dan Year	Research Title	Result
1.	Kurniasari *et al* (2023)	Pengaruh Hidroterapi Terhadap Penurunan Gula Darah Sewaktu (GDS) pada Pasien Diabetes Mellitus Tipe II	Hydrotherapy with drinking water therapy can reduce blood sugar levels with the average decrease in blood sugar levels during the treatment group being 52.5 mg/dL
2.	Margarita *et al* (2022)	Penerapan Hidrotherapi Sebagai Upaya Menurunkan Kadar Gula Darah Pada Pasien Diabetes Mellitus Type Ii Dengan Pendekatan Teori Keperawatan Orem Di Uptd Rsud Basemah Pagar Alam Tahun 2022	Warm drinking water therapy reduced blood glucose levels
3.	Arwansyah *et al* (2022)	Penerapan Hidrotherapi Sebagai Upaya Menurunkan Kadar Gula Darah Pada Pasien DM Type II Dengan Pendekatan Teori Keperawatan Orem	Warm drinking water therapy reduced blood glucose levels
4.	Putra *et al* (2022)	Hydroterapi minum air putih untuk menurunkan kadar gula darah sewaktu (GDS)	Drinking water therapy reduced mean blood glucose levels from 336.80 mg/dL to 212.13 mg/dL
5.	Savitri & Ratnawati (2022)	Buerger Allen Combination Therapy Exercises and Soak Feet Warm Water Lowers Blood Sugar Levels in Elderly with Diabetes Mellitus Type 2	The combination of warm water foot soaking and Buerger Allen exercises reduced blood glucose levels from 370.38 mg/dL to 151.19 mg/dL
6.	Istiroha *et al* (2022)	The Influence Of A Combination Of Walking Therapy And Hydrotherapy To Decrease Blood Glucose Levels In Patients With Diabetes Mellitus Type II	Drinking water therapy reduced blood glucose levels, with a mean decrease of 17.6 mg/dL.
7.	Damayanti *et al* (2021)	Pengaruh Hidroterapi Dan Relaksasi Benson Terhadap Kadar Gula Darah Pasien Diabetes Mellitus	Warm water foot soaking therapy reduced blood glucose levels
8.	Tarigan (2021)	Pengaruh Hidroterapi Terhadap Penurunan Kadar Gula Darah Sewaktu Pada Pasien Diabetes Mellitus Tipe 2 Di Puskesmas Binjai Serbangan Kabupaten Asahan Tahun 2020	Drinking water therapy reduced blood glucose levels from 274.09 mg/dL to 251.18 mg/dL.
9.	Siswanti *et al* (2021)	Hydrotherapy of Blood Glucose Level at Time for Deabetes Mellitus (DM) Patient	Drinking water therapy reduced blood glucose levels from 178.77 mg/dL to 157.59 mg/dL
10.	Saherna & Rezkiawan (2020)	The Effect Of Drinking Water On Hyperglycemia In Diabetes Mellitus	Drinking water therapy reduced mean blood glucose levels from 285.57 mg/dL to 139.71 mg/dL
11.	Mataputun *et al* (2020)	Efektivitas *Buerger Allen exercise* dibandingkan dengan Rendam Kaki Air Hangat terhadap Nilai *Ankle Brachial Index* dan Gula Darah pada Pasien Diabetes Mellitus	Warm water foot soaking was more effective than Buerger Allen exercises in reducing random blood glucose levels, with mean levels decreasing from 218.56 mg/dL to 198.59 mg/dL
12.	Wardani *et al* (2019)	The Effect Of Diabetic Feet Spa Therapy To Blood Glucose Level And Sleep Quality Of Diabetes Mellitus Patient	Warm water foot soaking therapy reduced mean blood glucose levels from 289.23 mg/dL to 124.57 mg/dL
13.	Jahidin *et al* (2019)	Pengaruh Terapi Minum Air Putih Terhadap Penurunan Kadar Gula Darah Sewaktu (GDS) Pada Pasien Diabetes Mellitus Tipe II	Drinking water therapy reduced mean blood glucose levels from 230.15 mg/dL to 166.10 mg/dL on day 7 and to 136 mg/dL on day 14

No.	Author dan Year	Research Title	Result
14.	Sholiha *et al* (2019)	Kombinasi Walking Exercise Dan Hydrotherapy Mempengaruhi Kadar Glukosa Darah Pada Penderita Diabetes Mellitus Tipe II	The combination of walking exercise and drinking water therapy reduced blood glucose levels from 220.29 mg/dL to 215.17 mg/dL.

A quasi-experimental study using a pre-test and post-test with control group design involved 58 respondents. The intervention group consisted of 18 respondents who received drinking water therapy at a dose of 1.5 liters per day for two weeks. The intervention resulted in a mean reduction in random blood glucose levels of 52.5 mg/dL (Kurniasari et al., 2023). A case study involving two respondents demonstrated that drinking 500–1,000 mL of water daily, including 640 mL consumed upon waking in the morning, for seven days could reduce blood glucose levels. However, the mean reduction in blood glucose levels was not reported (Margarita et al., 2022).

A case study involving two respondents who received warm drinking water therapy for five days demonstrated a reduction in blood glucose levels. However, the temperature and volume of water consumed were not specified, and the mean reduction in blood glucose levels was not reported (Arwansyah et al., 2022). A quasi-experimental study using a pre-test and post-test without control group design involving 15 respondents found that drinking six glasses of water daily, equivalent to approximately 1,500 mL, beginning in the morning after waking and continuing for 14 days, reduced mean blood glucose levels from 336.80 mg/dL to 212.13 mg/dL (Putra et al., 2022) .

A quasi-experimental study using a pre-test and post-test without control group design involving 16 respondents examined a combination of Buerger Allen exercises and warm water foot soaking. The intervention was administered 12 times over 15 days, three times per week, with two sessions per day at 08:00 and 16:00 Western Indonesia Time. Each session lasted 16 minutes, consisting of 10 minutes of foot soaking at a temperature of 38–39°C and six minutes of Buerger Allen exercises. The intervention reduced blood glucose levels from 370.38 mg/dL to 151.19 mg/dL (Savitri & Ratnawati, 2022). A quasi-experimental study using a pre-test and post-test with control group design involving 32 respondents demonstrated that drinking water therapy administered daily for three weeks according to body weight, with a minimum intake of 50 mL/kg/day and adjusted to elimination requirements of 1,500–1,600 mL/day plus insensible water loss of 500 mL per 24 hours, resulted in a mean reduction in blood glucose levels of 17.6 mg/dL (Istiroha et al., 2022).

A quasi-experimental study using a pre-test and post-test with control group design involving 34 respondents demonstrated that warm water foot soaking for 20 minutes daily over five consecutive days reduced blood glucose levels from 184.59 mg/dL to 162.94 mg/dL (Damayanti et al., 2021). A quasi-experimental study using a pre-test and post-test with control group design involving 22 respondents found that drinking a minimum of two liters of water per day, equivalent to approximately eight glasses, for one week reduced blood glucose levels from 274.09 mg/dL to 251.18 mg/dL (Tarigan, 2021).

A quasi-experimental study using a pre-test and post-test with control group design involving 34 respondents found that drinking 1.5 liters of water daily after waking in the morning for 14 days reduced blood glucose levels from 178.77 mg/dL to 157.59 mg/dL (Siswanti et al., 2021). A pre-experimental study using a static group comparison design involving 14 respondents demonstrated that drinking 800 mL of water daily, equivalent to four 200-mL glasses, at intervals of two to three hours between each glass for three consecutive days reduced mean blood glucose levels from 285.57 mg/dL to 139.71 mg/dL (Saherna & Rezkiawan, 2020).

A quasi-experimental study using a pre-test and post-test between two groups design involving 54 respondents found that warm water foot soaking at a temperature of 40–42°C, administered twice daily in the morning and afternoon for 15–20 minutes per session over five consecutive days, was more effective in reducing random blood glucose levels than Buerger Allen exercises (Mataputun et al., 2020). A quasi-experimental study using a pre-test and post-test with control group design involving 60 respondents demonstrated that warm water foot soaking at a temperature of 38–40°C reduced mean blood glucose levels from 289.23 mg/dL to 124.57 mg/dL. The duration of the intervention was not reported (Wardani et al., 2019a).

A quasi-experimental study using a pre-test and post-test without control group design involving 20 respondents found that drinking warm water for two weeks, at a dose of four to five 250-mL glasses

per day, reduced mean blood glucose levels from 230.15 mg/dL to 166.10 mg/dL on day 7 and subsequently to 136 mg/dL on day 14 (Jahidin et al., 2019). A quasi-experimental study using a pre-test and post-test with control group design involving 34 respondents demonstrated that drinking 1.5 liters of water daily after waking in the morning for 14 days reduced blood glucose levels from 220.29 mg/dL to 215.17 mg/dL (Sholiha et al., 2019).

3.2 Effects of Hydrotherapy on Ankle-Brachial Index in Type 2 Diabetes Mellitus

Table 2. *Literature Search Results Based on Theme 2*

No.	Author dan Year	Research Title	Result
1.	Yuningsih & Rosita (2022)	Pengaruh Hidroterapi Terhadap Peningkatan Sirkulasi Darah Perifer Pada Pasien Dm Di Wilayah Puskesmas Kelapa Dua, Tangerang	Warm water foot soaking resulted in a change in the mean ABI value from 1.1755 to 1.2060
2.	Maryama *et al* (2021)	Pengaruh Rendam Kaki Air Hangat Terhadap *Ankle Brachial Index* Pada Pasien Diabetes Melitus	Warm water foot soaking was beneficial in improving ABI values, from 0.771 to 1.052
3.	Fitriani & Aderita (2021)	Perawatan Kaki Spa Kaki Atasi Masalah Ketidakefektifan Perfusi Jaringan Perifer Pada Pasien Diabetes Millitus Tipe II	Foot soaking therapy reduced tingling and numbness and improved foot comfort. The ABI value changed from 1.3–1.4 to 1.1–1.2
4.	Simarmata *et al* (2020)	Effect of Cold Hot Water Soaking in the Feet on the Value of Ankle Brachial Index in Diabetes Mellitus Patients	Alternating warm and cold water foot soaking increased the ABI value from 0.127 to 0.823.
5.	Ibrahim *et al* (2020)	Perbandingan *Buerger Allen Exercise* Dengan *Foot Spa Diabetic* Terhadap Nilai *Ankle Brachial Index* Pada Pasien Diabetes Melitus Tipe II	Both Buerger Allen exercises and warm water foot soaking were effective in improving ABI values. However, based on the difference in mean values, warm water foot soaking demonstrated a greater mean improvement
6.	Mataputun *et al* (2020)	Efektivitas *Buerger Allen exercise* dibandingkan dengan Rendam Kaki Air Hangat terhadap Nilai *Ankle Brachial Index* dan Gula Darah pada Pasien Diabetes Mellitus	Warm water foot soaking increased the mean ABI value from 0.81 to 0.90
7.	Nugroho (2020)	Pengaruh Rendam Air Hangat Di Kaki Untuk Mencegah Terjadinya Ulkus Pada Penderita Diabtes Mellitus Di Dusun Kedungringin Desa Giripurwa Wonogiri	Warm water foot soaking increased the mean ABI value from 0.8010 before the intervention to 0.8830 after the intervention
8.	Djafar *et al* (2019)	Efektifitas *Foot Spa Diabetic* Terhadap Nilai *Ankle Brachial Index* Pada Pasien Diabetes Melitus Tipe II	Foot soaking therapy increased the ABI value from 0.8375 to 0.9625
9.	Wardani *et al* (2019)	The Effect Of Diabetic Foot Spa On *Ankle Brachial Index* And Foot Sensitivity Of Diabetes Mellitus Type 2	Foot soaking therapy increased the mean ABI value from 2.70 to 2.77.

A quasi-experimental study using a pre-test and post-test without control group design involving 20 respondents examined the effects of warm water foot soaking on the Ankle-Brachial Index (ABI). The intervention consisted of immersing the feet in warm water at 37–38°C for 15 minutes. The therapy resulted in a decrease in the mean ABI from 1.2060 to 1.1755. However, the study did not specify the number of days or frequency of intervention (Yuningsih & Rosita, 2022). A pre-experimental study using a one-group pre-test and post-test design involving 20 respondents demonstrated that warm water foot soaking was associated with changes in ABI. The mean ABI increased from 0.771 before the intervention to 1.052 after the intervention, indicating an improvement in peripheral arterial perfusion. The temperature of the water and duration of each treatment session were not reported (Maryama et al., 2021).

A case study involving three respondents evaluated warm water foot soaking as a hydrotherapy intervention. The therapy was administered once daily for five days, with each session lasting approximately 30 minutes. The intervention was associated with reductions in tingling and numbness, improved foot comfort, and changes in ABI from 1.3–1.4 to 1.1–1.2. The water temperature used for the intervention was not reported (Fitriani & Aderita, 2021). A quasi-experimental study using a pre-test and post-test with control group design involving 70 respondents investigated alternating warm and cold water foot soaking. The intervention consisted of immersing the feet in warm water at 38–42°C for four minutes, followed by cold water at 10–18°C for one minute. This sequence was repeated five times, with the final immersion performed in warm water, resulting in a total treatment duration of 24 minutes. The intervention was administered twice on separate mornings at the respondents' homes. The study reported an increase in ABI from 0.823 to 0.127 (Simarmata et al., 2021).

A quasi-experimental study using a pre-test and post-test two-group design involving 30 respondents compared warm water foot soaking with Buerger Allen Exercise. Warm water foot soaking was performed at 38°C for five minutes over five days in each intervention group. Both interventions were effective in increasing ABI; however, the mean difference was greater in the warm water foot-soaking group, with a mean difference of 0.113 compared with 0.050 in the Buerger Allen Exercise group (Ibrahim et al., 2020). A quasi-experimental study using a pre-test and post-test between-two-groups design involving 54 respondents evaluated warm water foot soaking at 40–42°C. The intervention was administered for five consecutive days, twice daily in the morning and afternoon, with each session lasting 15–20 minutes. The intervention increased the mean ABI from 0.81 to 0.90, suggesting improved peripheral arterial perfusion following warm water foot soaking (Mataputun et al., 2020)

A quasi-experimental study using a pre-test and post-test with control group design involving 10 respondents evaluated warm water foot soaking as an intervention for improving ABI. The mean ABI increased from 0.8010 before the intervention to 0.8830 after the intervention. However, the study did not report the duration, frequency, or number of treatment days, nor did it specify the temperature of the water used during the intervention (Nugroho, 2020). A quasi-experimental study using a two-group design involving 32 respondents evaluated different frequencies of warm water foot-soaking therapy. In the first group, the intervention was administered three times per week for three days, whereas the second group received the intervention five times per week for five days. The three-day intervention increased the mean ABI from 0.8687 to 0.9063, while the five-day intervention increased the mean ABI from 0.8375 to 0.9625. These findings suggest that the five-day intervention produced a greater improvement in ABI than the three-day intervention (Djafar et al., 2019).

A quasi-experimental study using a pre-test and post-test with control group design involving 60 respondents reported that warm water foot soaking increased the mean ABI from 2.70 to 2.77. However, the study did not report the duration, frequency, or number of treatment days, and the water temperature was also not specified (Wardani et al., 2019b).

4. DISCUSSION

The literature search identified 23 articles, comprising 14 articles on the effects of hydrotherapy on blood glucose levels in patients with type 2 diabetes mellitus (Table 1) and 9 articles on the effects of hydrotherapy on the Ankle-Brachial Index (ABI) in patients with type 2 diabetes mellitus (Table 2). The researchers subsequently screened the articles by reviewing their titles and abstracts according to the inclusion criteria. Ultimately, 23 articles were selected for analysis and categorized into two themes, as follows:

4.1 Effects of Hydrotherapy on Blood Glucose Levels in Patients with Type 2 Diabetes Mellitus

Blood glucose refers to the concentration of glucose circulating in the bloodstream and is an important indicator of glycemic status (Saha et al., 2020). According to the Ministry of Health of the Republic of Indonesia, a normal random blood glucose level is generally below 200 mg/dL, whereas a fasting blood glucose level below 126 mg/dL is considered within the non-diabetic range (Kementerian Kesehatan RI., 2020). Blood glucose levels fluctuate continuously in response to food intake, physical activity, hormonal regulation, and metabolic processes; therefore, maintaining glycemic levels within an appropriate range is essential for preventing diabetes-related complications (Artasensi et al., 2020).

Hyperglycemia is characterized by elevated blood glucose levels and is a major clinical feature of type 2 diabetes mellitus (Soep & Agussalim, 2020). Persistent hyperglycemia can adversely affect multiple physiological systems and increase the risk of diabetes-related complications when inadequately controlled (Naomi et al., 2021). Management of type 2 diabetes mellitus involves both pharmacological and non-pharmacological approaches (Kusna et al., 2020). Among non-pharmacological approaches, hydrotherapy, including adequate water intake and warm water foot soaking, has been investigated as a complementary intervention for improving glycemic control (Damayanti et al., 2021; Kurniasari et al., 2023).

Several studies have reported that adequate water intake may be associated with reductions in blood glucose levels among patients with type 2 diabetes mellitus. Water consumption after waking, with intervention periods ranging from 3 days to 3 weeks, was associated with improved glycemic outcomes across several studies (Arwansyah et al., 2022; Istiroha et al., 2022) The reported daily water intake ranged from approximately 800 to 2,000 mL. Adequate hydration may support renal function and urinary excretion, thereby contributing to fluid and metabolic homeostasis (Saherna & Rezkiawan, 2020). However, the reduction in blood glucose should not be interpreted as a direct consequence of water “dissolving” glucose. Rather, adequate hydration may influence glucose regulation indirectly through maintenance of circulating fluid volume, renal function, and urinary excretion, particularly when hyperglycemia is accompanied by increased urinary fluid loss (Jahidin et al., 2019).

Water consumption in the morning after waking has also been proposed as a practical strategy for maintaining adequate hydration. Following ingestion, water is absorbed primarily through the gastrointestinal tract and enters the systemic circulation, contributing to maintenance of fluid balance. Adequate hydration subsequently supports renal filtration and urinary excretion of metabolic waste products. Some studies have therefore suggested that maintaining adequate fluid intake may contribute to better glycemic regulation in patients with type 2 diabetes mellitus (Sholiha et al., 2019) From a nursing perspective, drinking-water hydrotherapy is relatively simple, inexpensive, accessible, and potentially feasible as a complementary strategy for supporting diabetes self-management (Putra et al., 2022). Nevertheless, fluid intake should be individualized according to the patient's clinical condition, particularly in patients with renal, cardiac, or other conditions requiring fluid restriction.

Warm water foot soaking represents another form of hydrotherapy investigated for glycemic management. Exposure of the feet to warm water at approximately 38–42°C can produce local vasodilation, increase peripheral blood flow, and promote muscular and vascular relaxation (Savitri & Ratnawati, 2022). Several studies have reported reductions in blood glucose following warm water foot-soaking interventions administered for periods ranging from 5 to 15 days (Mataputun et al., 2020). One proposed mechanism involves the physiological response to thermal exposure, including changes in peripheral circulation and metabolic activity. Heat exposure may also influence heat shock protein (HSP) responses, which have been associated with cellular stress adaptation and glucose metabolism. However, the direct contribution of HSPs to the reduction in blood glucose following warm water foot soaking remains insufficiently established and should therefore be interpreted cautiously (Damayanti et al., 2021).

Overall, the reviewed evidence suggests that hydrotherapy, particularly adequate water intake and warm water foot soaking, may have potential as a complementary non-pharmacological intervention for improving blood glucose control in patients with type 2 diabetes mellitus. The effects may involve different physiological pathways, with adequate hydration primarily supporting fluid and renal homeostasis, while warm water foot soaking may promote peripheral vasodilation, relaxation, and changes in metabolic activity. However, differences in intervention dose, duration, temperature,

frequency, and patient characteristics across studies indicate the need for further research using standardized protocols and adequately controlled designs.

4.2 Effects of Hydrotherapy on Ankle-Brachial Index in Type 2 Diabetes Mellitus

Type 2 diabetes mellitus is characterized primarily by insulin resistance, in which body cells respond inadequately to insulin, resulting in impaired glucose uptake and utilization (Sanches et al., 2023). Although the term non-insulin-dependent diabetes mellitus (NIDDM) has historically been used to describe type 2 diabetes mellitus, current terminology generally favors the term type 2 diabetes mellitus because insulin therapy may eventually be required in some patients (Zhang, 2022). Poorly controlled type 2 diabetes mellitus can contribute to vascular complications, including peripheral artery disease (PAD), which may impair blood flow to the lower extremities (Felício et al., 2019). Peripheral arterial circulation can be assessed non-invasively using the Ankle-Brachial Index (ABI), an established measure for detecting lower-extremity arterial insufficiency (Matsushita et al., 2019).

The ABI is a non-invasive vascular assessment that compares systolic blood pressure measured at the ankle with systolic blood pressure measured at the brachial artery and is widely used to identify peripheral arterial disease (Herraiz-Adillo et al., 2020). ABI measurement can be performed using a portable Doppler ultrasound device, commonly operating at a frequency of approximately 8–10 MHz, to detect arterial blood flow (Arkoudis et al., 2021). An ABI value of approximately 1.00–1.40 is generally considered normal, whereas a value below 0.90 indicates the possibility of peripheral arterial disease or impaired lower-extremity perfusion (Sirico et al., 2019).

The management of type 2 diabetes mellitus includes pharmacological and non-pharmacological approaches (Elsayed et al., 2023). Non-pharmacological interventions complement pharmacological treatment by supporting glycemic control, cardiovascular health, physical functioning, and prevention of diabetes-related complications (Lim et al., 2021). One non-pharmacological intervention that has been investigated for improving peripheral circulation in patients with diabetes mellitus is hydrotherapy, particularly warm water foot soaking (Wardani et al., 2019b).

Warm water foot soaking at approximately 37–38°C may promote peripheral vasodilation and increase local blood flow (Ibrahim et al., 2020; Yuningsih & Rosita, 2022). Exposure of the lower extremities to warm water can induce thermal vasodilation, facilitate peripheral circulation, and promote muscle relaxation (Djafar et al., 2019). The increase in tissue temperature may reduce vascular resistance and enhance blood flow to the exposed area, thereby potentially improving peripheral tissue perfusion (Fitriani & Aderita, 2021). These physiological responses provide a plausible basis for investigating warm water foot soaking as a complementary intervention for patients with diabetes who are at risk of peripheral circulatory impairment.

Warm water foot soaking also facilitates the transfer of heat from the water to the tissues of the lower extremities. Increased local circulation may support the delivery of oxygen and nutrients and facilitate the removal of metabolic waste products from peripheral tissues. These effects may be particularly relevant in patients with diabetes who experience impaired peripheral circulation (Nugroho, 2020). In addition, warm water foot soaking is relatively simple, inexpensive, and easy to administer, making it a potentially feasible complementary intervention in diabetes self-management and nursing care (Maryama et al., 2021).

The reviewed studies indicate that repeated warm water foot-soaking interventions may improve ABI among patients with type 2 diabetes mellitus. Interventions administered over three to five days were associated with increased ABI values in several studies, suggesting potential benefits of repeated thermal exposure on peripheral perfusion (Yuningsih & Rosita, 2022). However, the effects of hydrotherapy should not be considered independently of other aspects of diabetes management. Maintaining a healthy lifestyle, including appropriate physical activity, dietary management, medication adherence, and regular monitoring of vascular status, remains essential for maintaining peripheral vascular health and reducing the risk of complications (Mataputun et al., 2020).

Alternating warm and cold water immersion may provide another approach to hydrotherapy for peripheral circulation. Exposure to warm water promotes vasodilation, whereas brief cold exposure induces vasoconstriction. Repeated changes in vascular tone may influence local blood flow and peripheral circulation (Simarmata et al., 2021). However, the use of cold water should be carefully

controlled, particularly with respect to temperature and duration, because excessive or prolonged cold exposure may adversely affect peripheral tissues. Similarly, warm water should be maintained at a tolerable temperature to prevent thermal injury, especially in patients with diabetes who may have impaired peripheral sensation. Therefore, hydrotherapy should be performed using an appropriate temperature, duration, and frequency and should be accompanied by monitoring of skin integrity and patient tolerance (Mataputun et al., 2020).

5. CONCLUSIONS

Hydrotherapy shows potential as a complementary non-pharmacological intervention for patients with type 2 diabetes mellitus. The reviewed studies indicate that drinking water and warm water foot soaking may contribute to reductions in blood glucose levels through improved hydration, renal function, peripheral vasodilation, and relaxation. Warm water foot soaking may also improve peripheral perfusion, as reflected by changes in the Ankle-Brachial Index (ABI). However, variations in intervention temperature, duration, frequency, and treatment protocols limit direct comparison across studies. Therefore, hydrotherapy may be incorporated into nursing care as a simple, accessible, and low-cost complementary intervention, while standardized protocols and further rigorous studies are needed to establish its effectiveness.

ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to all individuals and institutions who provided support and assistance throughout the preparation and completion of this literature review.

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