

## Comparison of the Effects of Aquatic Therapeutic Exercise and Kinesio-taping on Blood Glucose Levels, Sensory-Motor Symptoms, and Neuropathic Pain in Women with Diabetic Peripheral Neuropathy

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### ABSTRACT

**Background:** Diabetic peripheral neuropathy (DPN) is a prevalent long-term complication of diabetes, characterized by severe pain, loss or reduction of sensation, and an increased risk of ulcers and amputations. The present study aims to compare the effects of aquatic therapeutic exercise (ATE) and kinesio-taping (KT) on blood glucose levels, sensory-motor symptoms, and neuropathic pain in women with DPN.

**Methods:** A quasi-experimental study was conducted with a causal-comparative approach and a pretest-posttest design. Twenty women with DPN (age:  $51.55 \pm 4.54$  years; height:  $160.50 \pm 3.77$  cm; weight:  $67.68 \pm 8.09$  kg) were randomly assigned to either an ATE group or a KT group. The ATE group performed Aquatic Therapeutic exercises for eight weeks. In the KT group, the tapes were continuously applied to the anterior and posterior muscles of the calf for eight weeks. A glucometer was used to assess blood glucose levels, and the Michigan neuropathy screening instrument was employed to evaluate neuropathy symptoms. Moreover, the LANSS pain scale was utilized to measure pain levels.

**Results:** The study findings revealed that both methods caused significant changes in symptoms and neuropathic pain; however, only the ATE significantly changed blood glucose levels ( $P < 0.05$ ). Additionally, no significant differences were observed between the effects of KT and ATE on neuropathic symptoms and pain between the two groups ( $P > 0.05$ ).

**Conclusions:** According to the results, while both methods have positive effects on improving neuropathy symptoms and reducing pain in women with DPN, only ATE reduces blood glucose levels in these individuals.

**KEY WORDS:** Aquatic Therapy, Athletic Tape, Blood Glucose, Diabetic Neuropathies, Psychomotor Performance.

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## Introduction

Diabetes mellitus is one of the most common groups of metabolic diseases characterized by chronic hyperglycemia [1]. The prevalence of diabetes among adults (aged 20-79 years) was 6.4% in 2010, affecting 285 million people, and will increase to 7.7%, or 439 million adults, by 2030 [1]. Diabetes presents two types of complications: microvascular and macrovascular [2]. One of the most frequently occurring microvascular complications is diabetic neuropathy [2]. This condition is categorized into autonomic neuropathy and sensorimotor neuropathy. While the former impairs the function of internal structures such as the cardiovascular, digestive, urinary, and reproductive systems, the latter primarily affects the neuromuscular system [3]. The three most frequent subtypes of sensorimotor diabetic neuropathy include peripheral polyneuropathy, focal neuropathy, and diabetic amyotrophy [3]. Peripheral polyneuropathy is the most prevalent type of diabetic neuropathy, accounting for at least 50% of patients with a 25-year history of type 2 diabetes [4]. Diabetic peripheral neuropathy (DPN) results in impaired blood flow and progressive degeneration of nerve fibers [3]. It predominantly affects the lower extremities, with symptoms including distal limb pain and numbness, which can increase the risk of ulceration [5].

DPN is associated with direct and indirect complications, including impaired balance, decreased muscle strength, and pain [6]. In DPN, the degeneration of sensory afferents leads to postural instability and defective proprioception in the lower extremities [7]. Muscle strength is another contributor to balance that is influenced by joint angle, muscle group, type of contraction, and contraction speed [8]. In this regard, studies suggest that in diabetic patients, the strength of the ankle flexor and extensor muscles decrease by 17% and 14%, respectively [9]. Therapeutic interventions for DPN include anti-depressant, anti-inflammatory, and anticonvulsant drugs [1]. Nevertheless, due to their side effects, some non-pharmacological interventions are used to improve DPN symptoms, including acupuncture, laser therapy, phototherapy, thermotherapy, kinesiotherapy, and hydrotherapy [10].

Aquatic exercise therapy has recently gained recognition as an effective adjunct for improving physical and motor functions in individuals with disabilities, with water buoyancy reducing joint stress [11]. This therapeutic modality can provide significant physiological advantages, particularly for patients experiencing sensorimotor disorders [12]. Consequently, aquatic exercises have been widely implemented as an effective intervention to mitigate the impact of peripheral neuropathy on the sensorimotor function of individuals with diabetes [11]. In support of this assertion, the study conducted by Sakinepoor et al. (2019) demonstrated that aquatic exercise yielded more favorable effects on balance and reaction time compared to resistance training in patients with DPN [13]. Similarly, Abasgholipour et al. (2021) compared the effects of in-water and land-based aerobic exercises on balance and postural sway in individuals with type II diabetes, noting that both interventions significantly improved balance [14].

Kinesio-tape is an elastic therapeutic tape commonly used in rehabilitation centers and sports settings to alleviate muscle spasms and pain, enhance muscle contraction, facilitate or inhibit muscle strength, increase range of motion, and improve blood and lymph circulation, as well as proprioception [15]. Importantly, kinesio-tapes are designed to support soft tissues while allowing normal physiological function [15].

Research findings suggest that kinesio-taping can improve proprioception and joint stability by inhibiting overactive muscles and facilitating weak muscles, thereby reducing pain, decreasing pressure on irritated nerve tissues, and altering muscle fibers' recruitment patterns depending on the direction and degree of stretch [16]. Generally, kinesio-tapes are assumed to facilitate a muscle when applied from its origin to its insertion and inhibit the muscle when applied in the opposite direction [17]. The increasing popularity of taping techniques among athletes, along with documented benefits for enhancing athletic performance, has generated considerable interest in utilizing kinesio-tape to improve physical capabilities and quality of life in patients with various sensorimotor disorders, including neuropathy. In this regard, Thakur et al. (2023) underscored the positive effects of kinesio-tape application on sensorimotor indices in patients with DPN [18]. Additionally, the study by Nesreen et al. (2022) reported the positive effects of kinesio-tape combined with traditional exercise on pain indicators and neuropathy symptoms in individuals with diabetic neuropathy [19].

Given the reduction in muscle strength among individuals with DPN [9], the importance of increasing muscle facilitation to improve muscle function, and the potential impact of improving muscle function on reducing the severity of neuropathic symptoms, this study follows two objectives: first, it examines the effect of kinesio-tape as a method of muscle facilitation on neuropathy symptoms; and, second, it compares the effects of kinesio-tape with one of the most widely used treatment protocols for alleviating neuropathy symptoms, namely, aquatic therapeutic exercise.

### **Material and Methods**

A quasi-experimental study was conducted with a pretest-posttest design. The study protocol was confirmed by the ethics committee of the University of Bojnord [IR.UB.REC.1403.018].

The research population consisted of women aged 40 to 60 diagnosed with DPN residing in Ferdows, South Khorasan Province, Iran. A convenience sample of 20 eligible women with DPN (age:  $51.55 \pm 4.54$  years; height:  $160.50 \pm 3.77$  cm; weight:  $67.68 \pm 8.09$  kg) was recruited from among those visiting the South Khorasan Diabetes Association. The sample size matched the total population precisely, given the number of individuals visiting the diabetes center.

The inclusion criteria for this study comprised a diagnosis of type 2 diabetes for a minimum duration of five years, as confirmed by a medical specialist. Participants were also required to have a diagnosis of diabetic neuropathy based on established clinical and laboratory diagnostic criteria; the ability to complete and a minimum score of 7 on balance assessments using the Michigan Balance Questionnaire; functional independence in daily activities; and absence of medical contraindications. Subjects' medication entailed metformin (500 mg) taken twice daily with meals. Participants were excluded if they had foot ulcers; uncontrolled cardiovascular or respiratory conditions; history of dizziness; uncontrolled hypertension; a history of resting tachycardia or arrhythmia; orthopedic problems or surgeries affecting walking; neurological complications other than diabetic neuropathy; and central nervous system disorders such as dementia, Parkinson's disease, or multiple sclerosis [18]. Also, participants who did not cooperate in implementing the research protocols and tests were excluded from the study.

An orientation session was held for all participants to familiarize them with the research and measurement procedures. The participants signed the written consent forms. They were assured that they could withdraw from the research at any stage of the tests or exercises without penalty. Moreover, they were assured that their personal and medical information would be kept confidential. In this single-blind randomized trial Participants were randomly assigned to hydrotherapy and kinesio taping groups using a simple randomization method. Participants were assigned to groups following a draw from numbered envelopes (Two groups of 10 participants).

### Kinesio-Taping

The kinesio-tape used in this study was Kindmax, a 5-centimeter-wide product made by Shanghai Kindmax Sports Products Co., Ltd in China. The tape was applied to the tibialis anterior, extensor digitorum longus, extensor hallucis longus, peroneus longus, and gastrocnemius muscles for 24 hours a day for eight weeks and replaced every five days (Fig. 1). The tape was applied at approximately half its original length, extending from the muscle's origin to its insertion [16].



Fig. 1: Taping of the anterior and posterior calf muscles

- Tibialis anterior muscle: Participants lay supine on a treatment table while the kinesio-tape was applied to their tibialis anterior muscles. The tape was anchored at the muscle's origin (lateral condyle) and extended along the proximal two-thirds of the anterolateral tibia. They were instructed to perform plantarflexion and eversion of their feet. Finally, the tape was tightened and secured at the muscle's insertion point (the lateral cuneiform bone surface).
- Extensor digitorum longus muscle: This muscle was covered with an inverted Y-shaped tape. The proximal end of the tape was anchored at the muscle's origin (lateral tibial condyle, distal three-quarters of the medial fibula, and interosseous membrane). The

participant was directed to dorsiflex the foot and extend the lateral four toes. The tape was then wrapped from the metatarsophalangeal joints to the middle and distal phalanges of the lateral four toes.

- Extensor hallucis longus muscle: An I-shaped tape was applied to this muscle. The tape was applied to the muscle from its fixed origin in the middle of the anterior surface of the ulna to the posterior aspect of the thumb's distal phalanx.
- Peroneus longus muscle: The participant lay supine when the long fibular muscle was taped. The tape was secured to the proximal and lateral aspects of the fibula, the muscle's origin. Subsequently, it was applied to the entire lateral surface of the leg, passed behind the lateral malleolus, and extended to and secured at the mid and lateral foot.
- Gastrocnemius muscle: The knee was fully extended to apply the tape on the gastrocnemius muscle. The tape was secured from the origin (posterior surface of the medial and lateral distal femoral condyles) to the posterior surface of the calcaneus.

#### Aquatic Therapeutic Exercise Protocol

The aquatic exercise group followed an 8-week training protocol consisting of three water-based exercise sessions per week, which included warm-up, stretching, and strengthening exercises (Table 1). The water temperature was kept at approximately 29 °C (between 28 °C and 30 °C) to avoid overheating [11].

**Table 1.** Aquatic exercise protocol

<b>Week</b>	<b>Warm-up (Each lasting 2 minutes)</b>	<b>Stretching exercises (6 repetitions, 10 seconds each)</b>	<b>Strengthening exercises (One set with 8 to 12 repetitions)</b>
<b>1 and 2</b>	Forward Walking, Backward Walking, Side Stepping	Calf Stretch, Hamstring Stretch, Shin Stretch, Quadriceps Stretch	Ankle Dorsiflexion, Ankle Plantarflexion, Ankle Eversion and Inversion, Ankle Alphabet, Toe Flexion and Extension
<b>3 and 4</b>	Forward Walking, Backward Walking, Crossover Stepping, Bicycle	Calf Stretch, Shin Stretch, Plantar Fascia Stretch, Lunge Stretch	Ankle Dorsiflexion, Ankle Plantarflexion, Ankle Eversion and Inversion, Heel Raises, Stork Stand, Side Stepping
<b>5 and 6</b>	Backward Walking, Crossover Stepping, Bicycle, Marching	Calf Stretch, Shin Stretch, Forefoot, Calf Stretch	Heel Raises, Stork Stand, Side Stepping, Leg Balance Exercises, Four-Corner Pivot, Toe Walking
<b>7 and 8</b>	Backward Walking, Crossover Stepping, Marching, Jogging, Leg Exchange	Soleus Stretch, Calf Stretch, Shin Stretch, Calf Stretch, Forefoot	Stork Stand, Side Stepping, Heel Raises, Toe Walking, Four-Corner Pivot, Leg Balance Exercises

## Blood Glucose Level

The EasyGluco glucometer manufactured by Osang HealthCare (Infopia, South Korea) was used to measure blood glucose levels. Capillary blood samples were collected from the participants' fingertips after a 10-hour fasting period and were measured and recorded by the glucometer. Fasting blood glucose levels were measured one day before the therapeutic interventions and one day after their completion [20].

## The LANSS Pain Scale

The LANSS pain scale is used to differentiate between patients with neuropathic pain and those without pain. It consists of a pain questionnaire and a sensory test. Participants are asked about their pain experiences during the past week, and responses are recorded as either yes or no. A score higher than 12 indicates the presence of neuropathic symptoms. The scale demonstrates good validity, effectively distinguishing between 73% and 75% of pain types. A positive correlation was identified between the individual item scores of the LANSS and the overall composite score, which suggests strong construct validity for the scale. The Cronbach's alpha for the scale was 0.81, indicating good internal consistency [18].

## Sensory-Motor Symptoms

The Michigan Neuropathy Screening Instrument was used to assess DPN symptoms. The Michigan questionnaire is a reliable and valid tool for assessing individuals with diabetic neuropathy. It consists of a clinical examination and an interview. In the clinical examination section, a score of 2 or higher indicates the presence of peripheral neuropathy. The interview section consists of 15 questions, and a score of 7 or higher suggests the likelihood of neuropathy. Individuals who scored 2 or higher in the clinical examination and 7 or higher in the interview are categorized as being at risk for diabetic foot ulcers. Notably, the validity and reliability of this tool have been previously confirmed [21].

## Statistical Analysis

The data were analyzed using version 16 of the statistical package in social sciences (SPSS, Chicago, United States) at a significance level of 0.05. First, the normal distribution of the data was confirmed using the Shapiro-Wilk test. Independent samples t-tests were employed to compare mean differences at baseline between groups. The paired t-test was used to assess within-group changes, while the analysis of covariance (ANCOVA) was utilized to compare between-group differences. The results are presented as mean  $\pm$  standard deviation.

## Results

Based on the results of the independent sample t-test (Table 2), at baseline, no significant differences were observed between the Aquatic Therapy and kinesio taping groups in terms of age, BMI, Height and Mass ( $p > 0.05$ ).

**Table 2.** Independent sample t-test results for comparing mean differences at baseline between Aquatic Therapy and kinesio taping groups.

Variable	Group	Mean	SD	t	Sig
Age (year)	Aquatic Therapy	51.900	4.677	0.336	0.953
	kinesio taping	51.200	4.638		
BMI (kg/m <sup>2</sup> )	Aquatic Therapy	26.871	3.289	0.732	0.831
	kinesio taping	25.752	3.540		
Height (cm)	Aquatic Therapy	160	3.559	0.582	0.568
	kinesio taping	161	4.109		
Mass (kg)	Aquatic Therapy	68.720	7.820	0.562	0.704
	kinesio taping	66.650	8.644		

Abbreviations: sig, Significance; SD, Standard Deviation.

According to the results of the paired t-test (Table 3), eight weeks of aquatic therapeutic exercise and the use of kinesio-tape in a facilitative approach led to significant changes in sensory-motor symptoms and neuropathic pain in women with DPN ( $P < 0.05$ ). However, only aquatic therapeutic exercise significantly changed blood glucose levels ( $P < 0.05$ ).

**Table 3.** Paired sample t-test results for research variables before and after aquatic therapeutic exercise and kinesio-taping

Variable	Independent variable	Mean	SD	t	Sig	Effect size (d)
Blood glucose levels (mg/dl)	Before aquatic exercises	150.300	15.004	3.440	0.007*	0.232
	After aquatic exercises	146.600	13.492			
	Before kinesio-taping	144.600	14.557	0.446	0.666	0.051
	After kinesio-taping	145.400	11.355			
Sensory-motor symptoms (Michigan Neuropathy scale)	Before aquatic exercises	11.900	2.079	2.689	0.025*	0.344
	After aquatic exercises	11.200	1.873			
	Before kinesio-taping	11.600	1.505	3.000	0.015*	0.236
	After kinesio-taping	11.100	1.286			
Neuropathic pain (LANSS pain scale)	Before aquatic exercises	16.300	1.636	4.714	0.001*	0.618
	After aquatic exercises	15.200	1.813			
	Before kinesio-taping	16.100	1.523	3.857	0.004*	0.548
	After kinesio-taping	15.200	1.686			

Abbreviations: sig, Significance; SD, Standard Deviation; \*,  $P < 0.05$ .

Additionally, based on the ANCOVA results (Table 4), there were significant differences in the effects of using kinesio-taping in a facilitative method and aquatic therapeutic exercise on blood glucose levels ( $P < 0.05$ ). However, no significant differences were observed between the effects of kinesio-taping and aquatic therapeutic exercise on sensory-motor symptoms and neuropathic pain.

**Table 4.** ANCOVA results to compare aquatic therapeutic exercise and kinesiio-taping groups

Variable	Levene's test	Sum of squares	Degrees of freedom	F	Sig
<b>Blood glucose levels (mg/dl)</b>	0.121	152.241	1	10.871	0.001*
<b>Sensory-motor symptoms</b>	0.217	0.106	1	0.269	0.611
<b>Neuropathic pain</b>	0.987	0.201	1	0.349	0.563

Abbreviations: sig, Significance; SD, Standard Deviation; \*, P<0.05.

## Discussion

This study aimed to examine the impact of aquatic therapeutic exercise and kinesiio-taping in a facilitative method on blood glucose levels, neuropathic pain, and neuropathy sensory-motor symptoms in women with DPN.

The current study's findings revealed that following 8 weeks of aquatic therapeutic exercise, there was a significant improvement in fasting blood glucose levels. In contrast, the kinesiio-taping group did not exhibit any significant improvement. Furthermore, a significant difference was observed between the effects of the aquatic therapy and kinesiio-taping interventions.

prior studies highlight the beneficial impacts of physical exercise on patients with diabetic neuropathy; however, the majority of exercise modalities focus on aerobic and balance training [22]. The study conducted by Shorabi et al. (2020) highlights the positive effects of aquatic exercise on lowering blood glucose levels in individuals with DPN [11], which is consistent with the current research findings.

Increased glucose levels in diabetic individuals lead to the glycosylation of proteins in the bloodstream, which results in numerous side effects in the long term. Glycation is a non-enzymatic increase in the sugar residues of amino groups in proteins [23]. Since diabetic patients have high blood sugar levels, they are more severely affected by this process compared to healthy individuals [23]. The role of physical activity in regulating blood sugar levels in type 2 diabetes may be attributed to the increased expression of glucose transporter GLUT4, which facilitates enhanced glucose uptake by muscle cells and promotes sugar consumption [24]. Aquatic exercise therapy facilitates the translocation of GLUT4 to the cell surface in diabetic individuals, thereby enhancing glucose uptake and lowering blood sugar levels. Conversely, using glycogen stores during exercise results in their depletion. This heightens the demand for glucose uptake to restore glycogen levels post-exercise, ultimately normalizing blood sugar levels [25]. Nonetheless, evidence suggests that kinesiio-taping as a facilitative method does not effectively lower blood sugar levels in individuals with diabetic neuropathy.

The findings of this study indicate that an 8-week regimen of aquatic therapy exercises combined with kinesiio-taping based on a facilitative approach improves sensory-motor symptoms and neuropathic pain significantly. However, no significant difference was observed between the effects of the two interventions. Previously, Dixit et al. (2014) reported that aerobic exercises for 8 weeks enhanced sensory-motor symptoms in patients with DPN [26]. Additionally, according to the study by Kluding et al. (2012), 11 weeks of combined aerobic and resistance exercise reduces pain and improves neuropathy symptoms in diabetic patients with peripheral neuropathy [27]. Furthermore, in line with the results of the present study,

the research by Nesreen et al. (2022) has demonstrated that 12 weeks of kinesiio-taping leads to a reduction in pain and improvement in neuropathy symptoms in patients with type 2 diabetes [19].

Neuronal mechanisms indicate that neuropathic pain arises as a result of long-term plasticity changes in pain transmission pathways in the brain and spinal cord. Lasting changes in the synaptic activities of the pain pathway neurons contribute to the emergence of neuropathic pain symptoms [28]. Decreased muscle strength and muscle mass are considered the main factors for pain and disability in patients with diabetic neuropathy. The current study indicates that participants experienced a significant reduction in pain sensation in both aquatic therapy and kinesiio-taping groups. This improvement may be attributed to the significant enhancement in the calves' anterior and posterior muscle strength resulting from these interventions. Warm water stimulates the skin and its underlying structures, leading to the dilation of cutaneous blood vessels, reduced striated muscle tone, and decreased peripheral vascular resistance. Enhanced blood circulation removes toxins and metabolites that intensify pain and boost aerobic metabolic activity, leading to pain alleviation [29]. Another factor that stimulates the skin during aquatic exercise is its activation of spinal sensory pathways, which induces relaxation. This process releases pain-triggering hormones and enzymes, reduces stimulation of pain receptors, and facilitates pain blockage. The reduction of compressive forces on weight and joints, along with the enhancement of blood circulation due to hydrostatic pressure from water, enables patients to engage in exercise in a low-fatigue, low-pressure, and low-stress environment. Collectively, these factors improve the patient's quality of life and reduce functional disability [30]. The potential reasons for the improvement of neuropathy symptoms can be attributed to the reduction of blood sugar levels and the enhancement of underlying factors, such as blood circulation to the peripheral nerves and limbs. Aquatic therapy exercises are an effective strategy for controlling blood sugar in diabetic patients, and there is a direct relationship between the level of neuropathy and blood sugar control in these patients. This study demonstrates that 8 weeks of aquatic therapy improved fasting blood sugar levels, which may have contributed to alleviating neuropathic symptoms.

Regarding the effects of kinesiio-taping on sensory-motor symptoms and neuropathic pain, it can be stated that kinesiio-taping stimulates joint receptors more effectively through applied pressure, heat, and skin stimulation, resulting in improved proprioceptive information and joint position sense in women with DPN [18]. The mechanism of action of kinesiio-taping in muscle facilitation is not completely clear; however, researchers have proposed two possible hypotheses. The first hypothesis emphasizes increased blood and lymph flow resulting from skin lifting, which increases the space between the skin and muscle as well as the interstitial space in the kinesiio-taping area. The second hypothesis suggests that kinesiio-taping stimulates cutaneous mechanoreceptors by inducing tension and pressure on the underlying skin, thereby activating regulatory mechanisms in the central nervous system that play a role in increasing muscle excitability [31]. Additionally, kinesiio-taping can provide tactile stimulation, which can explain the effects of kinesiio-taping used in a facilitative manner on the intensity of neuropathic pain. This stimulation may lead to the firing of large-diameter afferent fibers, which blocks the 'gate' to pain signals transmitted by small-diameter afferent fibers. Consequently, this stimulation results in a reduction of muscular and musculoskeletal pain [32].

## **Conclusion**

Based on the results of the present study, while both methods have positive effects on sensory-motor symptoms and neuropathic pain, only aquatic therapeutic exercise can reduce blood glucose levels in women with DPN. Apparently, the use of kinesiio-tape as a facilitative method enhances pain and sensory-motor symptoms in women with DPN by stimulating sensory receptors. Additionally, aquatic therapeutic

exercise contributes to improving sensory-motor symptoms and neuropathic pain in women with DPN by reducing blood glucose levels. In sum, both methods were found to improve symptoms and neuropathic pain, and individuals with DPN can utilize either of these two methods to alleviate their symptoms and pain, depending on the available resources.

### **Ethical Considerations:**

#### **Compliance with ethical guidelines**

The study protocol was ethically approved by the Ethics Committee in Biological Sciences Research affiliated with University of Bojnord [IR.UB.REC.1403.018].

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#### **Conflict of Interest**

The authors declare that there are no conflicts of interest regarding the publication of this manuscript

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#### **References**

1. Shaw JE, Sicree RA, Zimmet PZ. Global estimates of the prevalence of diabetes for 2010 and 2030. *Diabetes research and clinical practice*. 2010;87(1):4-14. DOI: [10.1016/j.diabres.2009.10.007](https://doi.org/10.1016/j.diabres.2009.10.007).
2. Chawla A, Chawla R, Jaggi S. Microvascular and macrovascular complications in diabetes mellitus: Distinct or continuum?. *Indian journal of endocrinology and metabolism*. 2016;20(4):546-51. DOI: [10.4103/2230-8210.183480](https://doi.org/10.4103/2230-8210.183480).
3. Vinik AI, Nevoret ML, Casellini C, Parson H. Diabetic neuropathy. *Endocrinology and metabolism clinics*. 2013;42(4):747-87. [https://www.endo.theclinics.com/article/S0889-8529\(13\)00052-2/abstract](https://www.endo.theclinics.com/article/S0889-8529(13)00052-2/abstract)
4. Booya F, Bandarian F, Larijani B, Pajouhi M, Nooraei M, Lotfi J. Potential risk factors for diabetic neuropathy: a case control study. *BMC neurology*. 2005;5:1-5. <https://link.springer.com/article/10.1186/1471-2377-5-24>
5. Rathur HM, Boulton AJ. The neuropathic diabetic foot. *Nature Clinical Practice Endocrinology & Metabolism*. 2007;3(1):14-25. DOI: [10.1038/ncpendmet0347](https://doi.org/10.1038/ncpendmet0347).
6. Cham MB, Mohseni-Bandpei MA, Bahramizadeh M, Forogh B, Kalbasi S, Biglarian A. Effects of vibro-medical insoles with and without vibrations on balance control in diabetic patients with mild-to-moderate peripheral neuropathy. *Journal of Biomechanics*. 2020;16;103:109656. DOI: [10.1016/j.jbiomech.2020.109656](https://doi.org/10.1016/j.jbiomech.2020.109656).
7. Nardone A, Grasso M, Schieppati M. Balance control in peripheral neuropathy: are patients equally unstable under static and dynamic conditions. *Gait & posture*. 2006;23(3):364-73. DOI: [10.1016/j.gaitpost.2005.04.002](https://doi.org/10.1016/j.gaitpost.2005.04.002).
8. Ghaderiyan M, Ghasemi GA. Comparison of the Amount and Ratio of Ankle Muscles Isometric Strength in Persons with Planus, Cavus and Normal Foot Types. *Studies in Sport Medicine*. 2017;20;8(20):53-72. DOI: [10.22089/smj.2017.898](https://doi.org/10.22089/smj.2017.898).

9. Andersen H, Nielsen S, Mogensen CE, Jakobsen J. Muscle strength in type 2 diabetes. *Diabetes*. 2004;1;53(6):1543-8 DOI: [10.2337/diabetes.53.6.1543](https://doi.org/10.2337/diabetes.53.6.1543)
10. Shanb AA, Youssef EF, Al Baker WI, Al-Khamis FA, Hassan A, Jatoi NA. The efficacy of adding electromagnetic therapy or laser therapy to medications in patients with diabetic peripheral neuropathy. *Journal of Lasers in Medical Sciences*. 2020;11(1):20. <https://pubmed.ncbi.nlm.nih.gov/articles/PMC7008750/>
11. Shourabi P, Bagheri R, Ashtary-Larky D, Wong A, Motevalli MS, Hedayati A, Baker JS, Rashidlamir A. Effects of hydrotherapy with massage on serum nerve growth factor concentrations and balance in middle aged diabetic neuropathy patients. *Complementary therapies in clinical practice*. 2020. 1;39:101141. DOI: [10.1016/j.ctcp.2020.101141](https://doi.org/10.1016/j.ctcp.2020.101141).
12. Lee BA, Oh DJ. The effects of aquatic exercise on body composition, physical fitness, and vascular compliance of obese elementary students. *Journal of exercise rehabilitation*. 2014;10(3):184. <https://pubmed.ncbi.nlm.nih.gov/articles/PMC4106774>.
13. Sakinepoor A, Naderi A, Mazidi M, Hashemian AH, Mirzaei M, Letafatkar A. Effect of resistance and aquatic exercises on balance in diabetes peripheral neuropathy patients: a randomized clinical trial study. *Journal of Diabetes Nursing*. 2019;10;7(4):968-82. <http://jdn.zbmu.ac.ir/article-1-390-en.html>
14. Abasgholipour A, Shahbazi M, Boroujeni ST, Ameri EA. The effects of in-water and on-land aerobic training on postural sway and balance in patients with type 2 diabetes. *International Journal of Diabetes in Developing Countries*. 2021;1:1-7. <https://link.springer.com/article/10.1007/s13410-021-00943-7>
15. Aghaie P, Abbasi A, Letafatkar A. The immediate effect of facilitatory and inhibitory Kinesio Taping on the muscular activity and fatigue of the elbow flexor muscles. *Studies in Sport Medicine*. 2021;13(29):207-28. DOI: [10.22089/smj.2021.11497.1540](https://doi.org/10.22089/smj.2021.11497.1540).
16. Ahmed AE, Mohamed NI, Mariam EM, Ahmed M. Effect of kinesiotape versus resistive exercise on dorsiflexors functional performance in diabetic peripheral neuropathy. *The Medical Journal of Cairo University*. 2020;1(88):1777-82. [https://mjcu.journals.ekb.eg/article\\_116827.html](https://mjcu.journals.ekb.eg/article_116827.html).
17. Nokhodchi N, Hosseini M, Attaran Iraj Z, Rahimi A. The Effects of Kinesio-tape through Facilitation of Hamstring and Inhibition of Quadriceps on Biomechanical Variables affecting Anterior Cruciate Ligament Injury When Landing in Active Healthy Young Women. *Journal of Advanced Sport Technology*. 2020;4(2):104-13. [https://jast.uma.ac.ir/article\\_1080.html](https://jast.uma.ac.ir/article_1080.html).
18. Thakur K, Goyal M. Effectiveness of neuromuscular taping on balance, proprioception, pain, and nerve conduction parameters in patients with diabetic peripheral neuropathy: a two-group pretest-posttest randomized sham-controlled trial study protocol. *Journal of Diabetes & Metabolic Disorders*. 2023;22(2):1793-800. <https://link.springer.com/article/10.1007/s40200-023-01275-5>
19. Nesreen G, Sally A, Louis N, Mubarak L, Heba R. Effects of Kinesio Tapping on Diabetic Peripheral Neuropathy Symptoms in Type II Diabetes. *The Medical Journal of Cairo University*. 2022;1(9):1309-15. [https://journals.ekb.eg/article\\_264484.html](https://journals.ekb.eg/article_264484.html)
20. Thomas E, Ficarra S, Nakamura M, Drid P, Trivic T, Bianco A. The effects of stretching exercise on levels of blood glucose: a systematic review with Meta-analysis. *Sports medicine-open*. 2024;10(1):15. <https://link.springer.com/article/10.1186/s40798-023-00661-w>

21. Kazamel M, Stino AM, Smith AG. Metabolic syndrome and peripheral neuropathy. *Muscle & Nerve*. 2021;63(3):285-93. DOI: [10.1002/mus.27086](https://doi.org/10.1002/mus.27086).
22. Streckmann F, Balke M, Cavaletti G, Toscanelli A, Bloch W, Décard BF, Lehmann HC, Faude O. Exercise and neuropathy: systematic review with meta-analysis. *Sports Medicine*. 2022;52(5):1043-65. <https://link.springer.com/article/10.1007/s40279-021-01596-6>
23. Hanachi, P., Heydari, M. R., & Nikbakht, H. A Comparison between lipid Peroxidation Products & Hemoglobin in Patients of Diabetes T.2 with Normal People. *J. Ilam Uni. Med. Sci.* 2008;16(1):43-48. <http://sjimu.medilam.ac.ir/article-1-14-fa.html>
24. Taguchi T, Kishikawa H, Motoshima H, Sakai K, Nishiyama T, Yoshizato K, Shirakami A, Toyonaga T, Shirotani T, Araki E, Shichiri M. Involvement of bradykinin in acute exercise-induced increase of glucose uptake and GLUT-4 translocation in skeletal muscle: studies in normal and diabetic humans and rats. *Metabolism-Clinical and Experimental*. 2000;49(7):920-30. DOI: [10.1053/meta.2000.6755](https://doi.org/10.1053/meta.2000.6755)
25. Rose AJ, Richter EA. Skeletal muscle glucose uptake during exercise: how is it regulated?. *Physiology*. 2005;20(4):260-70. DOI: [10.1152/physiol.00012.2005](https://doi.org/10.1152/physiol.00012.2005).
26. Dixit S, Maiya AG, Shastri BA. Effect of aerobic exercise on peripheral nerve functions of population with diabetic peripheral neuropathy in type 2 diabetes: a single blind, parallel group randomized controlled trial. *Journal of Diabetes and its Complications*. 2014;1;28(3):332-9. DOI: [10.1016/j.jdiacomp.2013.12.006](https://doi.org/10.1016/j.jdiacomp.2013.12.006).
27. Kluding PM, Pasnoor M, Singh R, Jernigan S, Farmer K, Rucker J, Sharma NK, Wright DE. The effect of exercise on neuropathic symptoms, nerve function, and cutaneous innervation in people with diabetic peripheral neuropathy. *Journal of Diabetes and its Complications*. 2012;26(5):424-9. DOI: [10.1016/j.jdiacomp.2012.05.007](https://doi.org/10.1016/j.jdiacomp.2012.05.007)
28. Parsa TA, Hosseini SA, Bije N, Nia MH. The study of the effect of a 16-week program of resistance-aerobic training on BDNF, Hba1c, pain, and michigan neuropathy score among type 2 diabetic patients with peripheral neuropathy. *J Diabetes Metab*. 2018;1;9(11). DOI: [10.4172/2155-6156.1000811](https://doi.org/10.4172/2155-6156.1000811).
29. Lee BA, Oh DJ. The effects of aquatic exercise on body composition, physical fitness, and vascular compliance of obese elementary students. *Journal of exercise rehabilitation*. 2014;10(3):184. <https://pubmed.ncbi.nlm.nih.gov/articles/PMC4106774/>
30. Ragab IM. Aquatic therapy versus combined aquatic and land-based therapy in the treatment of chronic lateral ankle sprain. *Egyptian Journal of Physical Therapy*. 2020;2(1):16-23. DOI: [10.21608/ejpt.2020.32561.1008](https://doi.org/10.21608/ejpt.2020.32561.1008).
31. Konishi Y. Tactile stimulation with Kinesiology tape alleviates muscle weakness attributable to attenuation of Ia afferents. *Journal of Science and Medicine in Sport*. 2013;1;16(1):45-8. DOI: [10.1016/j.jsams.2012.04.007](https://doi.org/10.1016/j.jsams.2012.04.007).
32. Lu Z, Li X, Chen R, Guo C. Kinesio taping improves pain and function in patients with knee osteoarthritis: A meta-analysis of randomized controlled trials. *International Journal of Surgery*. 2018;1(59):27-35. DOI: [10.1016/j.ijssu.2018.09.015](https://doi.org/10.1016/j.ijssu.2018.09.015).



## مقایسه اثر ورزش درمانی در آب و کینزیوتیپ بر سطوح گلوکز خون، علائم حسی - حرکتی و درد نوروپاتی در زنان مبتلا به نوروپاتی محیطی دیابتی

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### چکیده

**هدف:** نوروپاتی دیابتی یکی از شایع ترین عوارض بلند مدت دیابت است که با درد شدید، کاهش و فقدان حس و افزایش خطر ایجاد زخم و قطع عضو همراه است. هدف از تحقیق حاضر، مقایسه اثر ورزش درمانی در آب و کینزیوتیپ بر سطوح گلوکز خون، علائم حسی - حرکتی و درد نوروپاتی در زنان مبتلا به نوروپاتی محیطی دیابتی می باشد.

**روش شناسی:** پژوهش حاضر نیمه تجربی و از نوع تحقیقات علی مقایسه‌ای با طرح تحقیق پیش و پس آزمون می‌باشد. در این مطالعه ۲۰ زن (سن  $51/55 \pm 4/54$  سال، قد  $160/50 \pm 3/77$  سانتی متر و وزن  $67/68 \pm 8/09$  کیلوگرم) مبتلا به نوروپاتی محیطی دیابتی به صورت تصادفی در دو گروه ورزش درمانی در آب و کینزیوتیپ تقسیم شدند. گروه ورزش درمانی در آب به مدت هشت هفته تمرینات آب درمانی را انجام دادند. در گروه کینزیوتیپ، تیپ ها به صورت شبانه روزی و به مدت ۸ هفته روی عضلات قدام و خلف ساق اعمال می شدند. به منظور بررسی سطوح گلوکز خون از دستگاه گلوکومتر و به منظور بررسی علائم نوروپاتی از آزمون میشیگان و به منظور بررسی میزان درد از ابزار سنجش درد نوروپاتی LANSS استفاده گردید.

**نتایج:** نتایج نشان داد که هر دو روش سبب ایجاد تغییرات معنی داری در علائم و درد نوروپاتی شدند با این حال فقط گروه ورزش درمانی در آب سبب ایجاد تغییرات معنی داری در سطوح گلوکز خون شد ( $P < 0.05$ ). همچنین میان اثر کینزیوتیپ و ورزش درمانی در آب بر علائم نوروپاتی و درد نوروپاتی میان دو گروه تفاوت معنی داری مشاهده نگردید ( $P > 0.05$ ).

**نتیجه گیری:** بر اساس نتایج تحقیق می توان بیان داشت ضمن دارا بودن اثرات مثبت هر دو روش بر بهبود علائم نوروپاتی و کاهش درد در زنان مبتلا به نوروپاتی محیطی دیابتی، تنها استفاده از روش ورزش درمانی در آب سبب کاهش سطوح گلوکز خون در این افراد شد.

**واژه‌های کلیدی:** ورزش درمانی در آب، کینزیوتیپ، گلوکز خون، نوروپاتی دیابتی، علائم حسی - حرکتی