

Araştırma Makalesi/ Research Article

Feet Health of Diabetic Hemodialysis Patients and Type 2 DM Patients: A Cross-Sectional and Comparative Study

Diyabetik Hemodiyaliz Hastaları ve Tip 2 DM Hastalarının Ayak Sağlığı: Kesitsel ve Karşılaştırmalı Bir Çalışma

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Geliş tarihi/ Date of receipt: 20/10/2024

Kabul tarihi/ Date of acceptance: 02/10/2025

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ABSTRACT

Objective: The two most important microvascular complications of Diabetes Mellitus (DM) are diabetic nephropathy and diabetic foot. This study was conducted to investigate and compare the foot health of diabetic hemodialysis (DHD) and Type 2 DM (T2DM) patients in terms of diabetic foot ulcer development.

Methods: This is a cross-sectional and comparative study. The study was conducted in the hemodialysis and endocrine clinics of a state hospital. The study was conducted with 34 DHD patients and 62 T2DM patients. The data of the study were collected through the personal information form and diabetic foot evaluation form. The data were evaluated in the SPSS 25 analysis program.

Results: In the study, 59% of DHD patients and 73% of type 2 DM patients were female. Years of diabetes were 20.64±10.25 (4-39) in the DHD group and 16.27±7.0 (3-40) in the T2 DM group. DHD patients received dialysis on average three days a week. Ankle-brachial index was 0.76±0.10 (0.59-1.00) in the DHD group and 0.91±0.09 (0.71-1.09) in the T2DM group and was statistically significant (p<0.000). Among the protective sensory tests, the sense of touch was 2.38±3.67 in the DHD group and 4.38±4.03 in the T2 DM group and there was a statistically significant difference (p=0.005). There was a difference between the groups in vibration sense (p<0.000). 69% of T2DM patients and 88% of DHD patients are at high risk (p=0.040).

Conclusion: DHD patients have decreased protective sensations, increased neuropathy, decreased foot blood circulation and moderate ischemia in their feet compared to the other group. It was concluded that DHD patients are more prone to developing foot ulcers compared to the T2DM group.

Keywords: Hemodialysis, diabetic nephropathy, diabetic neuropathy, diabetic foot, diabetic foot examination, type 2 diabetes

ÖZ

Amaç: Diyabetes Mellitus (DM)'un en önemli iki mikrovasküler komplikasyonu diyabetik nefropati ve diyabetik ayakdır. Bu çalışma diyabetik hemodiyaliz (DHD) ve tip 2 diyabet (T2DM) hastalarının ayak sağlıklarını diyabetik ayak ülseri gelişimi açısından incelemek ve karşılaştırmak amacıyla yapılmıştır.

Yöntem: Bu kesitsel ve karşılaştırmalı bir çalışmadır. Çalışma bir devlet hastanesinin hemodiyaliz ve endokrin kliniklerinde yapılmıştır. Çalışma 34 DHD hastası ve 62 T2DM hastası ile yürütülmüştür. Araştırmanın verileri kişisel bilgi formu ve diyabetik ayak değerlendirme formu aracılığıyla toplanmıştır. Veriler SPSS 25 analiz programında değerlendirilmiştir.

Bulgular: Çalışmada DHD hastalarının %59'u, tip2 DM hastalarının ise %73'ü kadındır. Diyabet yılı DHD grubunda 20,64±10,25 (4-39), type2 DM grubunda ise 16,27±7,0 (3-40)'dır. DHD hastaları haftada ortalama üç gün diyalize girmektedir. Ayak bileği-kol indeksi DHD grubunda 0,76±0,10 (0,59-1,00), T2DM grubunda 0,91±0,09 (0,71-1,09)'dur ve istatistiksel olarak anlamlıdır (p<0,000). Koruyucu duyu testlerinden dokunma duyası DHD grubunda 2,38±3,67, T2DM grubunda 4,38±4,03 ve istatistiksel fark vardır (p=0,005). Titreşim duyasında gruplar arasında fark vardır (p<0,000). T2DM hastalarının %69'u ve DHD hastalarının %88'i yüksek risk altındadır (p=0,040).

Sonuç: DHD hastalarında diğer gruba kıyasla koruyucu duylarda azalma, nöropatide artış, ayak kan dolaşımında azalma ve ayaklarında orta düzeyde iske mi vardır. T2DM grubuna göre DHD hastaları, ayak ülseri gelişimine daha yakın olduğu sonucuna varıldı.

Anahtar Kelimeler: Diyabetik nefropati, diyabetik nöropati, diyabetik ayak, diyabetik ayak muayenesi, hemodiyaliz, tip 2 diyabet

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Citation: Eraydın Ş. (2026). Feet health of diabetic hemodialysis patients and type 2 DM patients: A cross-sectional and comparative study. Ordu Üniversitesi Hemşirelik Çalışmaları Dergisi. 9(4), 666-674. DOI:1038108/ouhcd.1570503



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Introduction

Diabetes Mellitus (DM) developed when the pancreas cannot produce insulin or body cannot use the produced insulin sufficiently (ADA, 2024a; ADA, 2024b). The International Diabetes Federation indicates that 9.3% of adults aged 20-79 years-463 million people - live with Type 2 Diabetes Mellitus in the world (ADA, 2024a; ADA, 2024b; IDF, 2019). DM is common all over the world and it is the root cause of many comorbid diseases. Two of the major microvascular complications of DM are diabetic nephropathy and diabetic foot (ADA, 2024b; TÜRKDİAB, 2019).

Diabetic nephropathy develops in 20-40% of DM patients and diabetic kidney disease occurs as a result of nephropathy (ADA, 2024b; Cheng et al., 2021; Khan et al., 2020; Khanijou et al., 2022;). Diabetic nephropathy is characterized by albuminuria, a decline in glomerular filtration rate, hypertension, mesangial matrix expansion, glomerular basement membrane thickening, and tubulointerstitial fibrosis (Giralt-López et al., 2020). Chronic systemic inflammation and the inflammatory response, such as increased circulating cytokines (Interleukins), have been recognized as main players in the development and progression of diabetic kidney disease. Kidney insulin clearance characteristics and the capability of the kidney might be different because of pathophysiological processes (Van Baar et al., 2022). Proteinuria is increased in end-stage renal disease (Khan et al., 2020). Hemodialysis (HD) treatment has been applied as a part of the treatment in DM patients who develop renal failure due to diabetic nephropathy (Koch et al., 2020; TÜRKDİAB, 2019). It was reported that 38% of the patients who received new renal replacement treatment in Türkiye in 2017 had DM and that their kidney damage developed because of nephropathy (Nephrology Association Report, 2017).

Diabetic foot that develops as a result of neuropathy and peripheral artery disease in DM patients causes Diabetic Foot Ulcer (DFU) that can result in amputation (ADA, 2024a; ADA, 2024b). The prevalence of DFU in DM patients is 4%, and its annual incidence rate is 2-6%. Lifetime DFU incidence rate is 34% (Wexler, 2020). About 40-60% of all non-traumatic lower extremity amputations are due to DM, and reamputation rates are high. Besides, 20% of DFU infections could lead to amputation (TÜRKDİAB, 2019). In previous studies conducted on DM patients with renal failure who received diabetic hemodialysis (DHD) there

was a close relationship between HD treatment and the onset of DFU (Liu et al., 2021; Kaminski et al., 2015; Rodrigues et al., 2022; Schembri and Formosa, 2022). Studies have revealed that chronic kidney disease, end-stage renal disease and HD treatment are also risk factors in the development and course of DFU (Al-Nakeeb et al., 2021; Doria et al., 2016; Garimella et al., 2017; Özdemir and Nural, 2021;). DFU, a chronic complication of diabetes, causes high mortality and morbidity, but it is a preventable health problem (ADA, 2024a; IDF, 2019).

Nephropathy and neuropathy can be at risk for DFU. DFU effect can be even more pronounced when the consequences of diabetes, such as neuropathy, angiopathy and damage to the feet, joints and blood vessels (ADA, 2024a; ADA, 2024b). That are combined with high creatine levels caused by renal failure, protein deficiency and the presence of urea in the skin (Al-Thani et al., 2014; Kaminski et al., 2017). This regard, nurses and healthcare professionals must be ready for DM complications. Evaluation of neuropathy damage in the feet of DHD patients is necessary to maintain foot health. Risk factors for DFU in DM patients have been extensively studied in Türkiye (Biçer and Çelik, 2016; Nural and Hindistan, 2016; Kafadar and Kemaloğlu, 2020; Yürekli et al., 2018). Although studies have separately examined the risk of DFU in patients with T2DM and HD patients, no research has been found that directly compares the risk of DFU between T2DM patients undergoing HD treatment and patients not undergoing dialysis. This study addresses this critical gap by providing fundamental evidence for preventive care strategies through a direct comparison of the risk of DFU development between these two distinct patient populations. The results of this study provide important clinical evidence for protective-preventive care strategies by revealing the DFU risk profile through a comparative analysis between the two patient groups.

Objective

This study was conducted to examine and compare the foot health of DHD and T2DM patients in terms of diabetic foot ulcer development.

Research Questions

1. What is the level of foot health of DHD patients and T2DM patients?
2. Is there a difference between DHD patients and T2DM patients in terms of the risk of developing DFU?

Methods

Design and Setting

This research is cross-sectional and comparative study. The research was conducted between March 15 and September 15, 2019.

Study Population and Sample

The study was conducted in the hemodialysis and endocrine clinics of a State Hospital. The DHD group was selected from dialysis patients while other patients were selected among T2DM patients of endocrine clinic. Sample size was calculated by G*power 3.1.9.4 software. A prevalence level of 5% (Garimella et al., 2017) was used for the DHD group and 24% (Doria et al., 2016) for the T2DM group, giving 80% power and a margin of error of 5%. The study was completed with 34 people in the DHD group and 62 people in the T2DM group. Patients were made up of adult individuals between the ages of 20 and 80 who without DFU were diagnosed with T2DM for at least one year. Patients without amputation, peripheral circulatory problems, stroke, neurologic disease, muscle disease, lower extremity fracture and trauma were selected for the sample.

DHD group: This group consisted of adults aged 20-80 who had been diagnosed with T2DM, did not have DFU, and had been receiving HD treatment for at least one year. The DHD group consisted of 34 patients. Characteristics of HD treatment in these patients.

Characteristics	X±SD (Min–Max)
HD treatment year	4.01±3.07 (1–15)
Number of HD per week	3.05±0.85 (2–7)
HD Time (Hours)	3.47±0.36 (3–4)

Type 2 DM group: This group was made up of adult individuals between the ages of 20 and 80 who were diagnosed with Type 2 diabetes for at least one year. The T2DM group consisted of 62 patients.

Exclusion criteria: The patients who could not communicate, who had full foot amputation, who DFU is available, who received surgical treatment for DFU and who wanted to withdraw from the research were excluded from the study. Patients with diagnosed advanced heart disease, advanced peripheral arterial disease, venous insufficiency and hemiplegic were not included in the sample.

Data Collection

The data of the study were collected in the hemodialysis and endocrine clinics of a public hospital. The data of the study was collected by the researcher using data collection tools (Personal Information Form and Diabetic Foot Evaluation

Form). The data of the study and height and weight measurements of DHD patients were made after dialysis treatment. Height and weight measurements of T2DM patients were made in the clinic.

Data Collection Tools

Personal Information Form: This form was prepared based on literature (Biçer and Çelik, 2016; Garimella et al., 2017; Özdemir and Nural 2021) and included a total of 20 questions to determine the individual characteristics health (gender, age, educational status, body mass index, eg.) and disease characteristics (year of diabetes, diabetes treatment, dietary compliance, eg.), the foot problems (previous DFU, partial amputation, eg.) of patients in both groups and hemodialysis parameters (HD treatment year, number of HD per week, HD time /hours eg.) of DHD patients.

Diabetic Foot Assessment Form: This form was developed by the Turkish Diabetes Nurses Association. This form used by nurses evaluates the foot health of DM patients. Inspection, palpation, auscultation and olfaction examination methods are used. The form examines the physical condition and sensory perception of both the leg and the foot. Foot muscle strength, foot circulation, foot structure and deformities are examined. Scoring is done for each area, and the feet health risk status is determined. The Ankle-Brachial Index (ABI) is calculated by dividing the tibialis posterior pressure by the brachial artery pressure. (Biçer and Çelik, 2016). Normally, the ABI value varies between 0.9 and 1.1 (Thompson et al., 2020). The 5.07 plastic monofilament used in feet examination is to bend when a force of 10 g is applied. This pressure is applied to specific points located on the plantar and dorsal sides of the feet (Biçer and Çelik, 2016).

Data Analysis

The data of the study were evaluated by IBM SPSS 22.0 software (IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp). Descriptive statistics were presented as numbers, percentages, mean±standard deviation and median. The conformity of the quantitative data to the normal distribution was analyzed with the skewness-kurtosis, Shapiro–Wilk Test. Normally distributed continuous data were presented as mean ± SD, and not normally distributed continuous data were shown as Median (minimum–maximum), and Mann–Whitney U-test was made for comparisons. The comparisons between the groups were made using independent t test, and Chi-Square test. p<0.05 was considered statistical significance level.

Results

Demographic and disease characteristics of the patients in the study are given in Table 1. In T2DM group 72.6% of the patients were women, 62.9% were married and 50% were not literate. The average duration of diabet was 16.27 ± 7.0 years. In DHD group, 58.8% of the patients were women, 70.6% of them were married and 44.1% of them were elementary school graduates. The average duration

of diabet was 20.64 ± 10.25 years in DHD patients. There was no difference between the patients' characteristics such as body mass index, year of diabetes, mean age in both groups ($p > 0.05$). 3.2% of T2DM patients and 26.5% of DHD patients had sufficient level of foot care information ($p = 0.001$). In 22.6% of T2 DM patients, and 50% of DHD patients, there were previous wounds on feet's ($p = 0.006$) (Table1).

Table 1. Patients' demographic characteristics and disease information

		T2DM Group (n=62)		DHD Group (n=34)		Test and P
Characteristics		n	%	n	%	χ^2 test*
Gender	Female	45	72.6	20	58.8	0.180
	Male	17	27.4	14	41.2	
Education status	Illiterate	31	50	9	26.5	-
	Literate	4	6.5	1	2.9	
	Primary school	23	37.1	15	44.1	
	Middle School	3	4.8	4	11.8	
	High school	1	1.6	4	11.8	
	College / faculty	-	-	1	2.9	
Marital status	Married	39	62.9	24	70.6	0.506
	Single	23	37.1	10	29.4	
Working status	Working Active	2	3.2	3	8.8	0.343
	Not working	60	96.8	31	91.2	
Residence	City Center	36	58.1	24	70.6	0.163
	Village	25	40.3	8	23.5	
	County	1	1.6	2	5.9	
Smoking	Never used	51	82.3	23	67.6	0.175
	Used up	5	8.1	9	26.5	
	Uses	6	9.7	2	5.9	
Diabetes treatment	Insulin	39	62.9	34	100	-
	Oral medication	23	37.1	-	-	
Dietary compliance	Good	15	24.2	5	14.7	0.537
	Middle	9	14.5	5	14.7	
	Bad	38	61.3	24	70.6	
Receiving Diabetic Foot Care Training	Yes	2	3.2	9	26.5	0.001
	No	60	96.8	25	73.5	
Previous DFU	Yes	14	22.6	18	53	0.006
	No	48	77.4	16	47	
Partial Amputation	Yes	-	-	2	5.9	-
	No	62	100	32	91.2	
		X $\pm$ SD(Min-Max)		X $\pm$ SD(Min-Max)		
Average Age (years)		63.56 $\pm$ 7.85 (44-78)		66.82 $\pm$ 9.79 (35-80)		0.079†
Year of Diabetes		16.27 $\pm$ 7.0 (3 - 40)		20.64 $\pm$ 10.25 (4 - 39)		0.310†
BMI average (kg/m ²)		31.21 $\pm$ 5.01 (20.03 - 45.79)		27.32 $\pm$ 6.33 ** (16.67 - 44.92)		0.100†

* χ^2 test, †Student t test ** weight measurement after dialysis

Table 2 contains the findings of extensive foot examination. In 14.5% of T2 DM patients and 76.5% of DHD patients, feet were cold ($p=0.000$). In addition, 82.3% of T2 DM patients and 85.3% of DHD patients had dry feet's ($p=0.040$), while 30.6% of T2 DM patients and 50% of DHD patients had very weak feet's pulses. The feet color was pale in 6.5% of T2 DM patients and 70.6% of DHD patients ($p=0.000$). In terms of the nail shape of the patients, 46.8% of T2 DM patients and 70.6% of DHD patients had deformed nails. Skin between the toes was macerated in 25.8% T2 DM patients and 20.6% of DHD patients. There were cracks in the feet of 22.6% of T2 DM patients and 76.5% of DHD patients ($p=0.000$). Callous was evident in the feet of 87.1% of T2 DM patients and 97.1% of DHD patients. Foot muscle strength was reduced in 25.8% of T2 DM patients and 58.8% of DHD patients ($p=0.006$). Hallux vagus was observed in 25.8% of

T2 DM patients and 47.1% of DHD patients ($p=0.024$) (Table2).

Foot muscle strength was reduced in 25.8% of T2DM patients and 58.8% of DHD patients ($p=0.006$). Hallux vagus was observed in 25.8% of T2DM patients and 47.1% of DHD patients ($p=0.024$) In Monoflam 10 g pressure sensory test for patient feet, the average number of points between 0-10 in the feet of patients was 4.38 ± 4.03 in T2DM patients and 2.38 ± 3.67 in DHD patients ($p=0.005$). In vibration test performed with 128 Hz diapason in the feet of patients, 17.7% of T2DM patients and 76.5% of DHD patients had no sense of vibration ($p=0.000$). In foot examination, ankle-brachial index was 0.76 ± 0.10 (0.59-1.00) in DHD group and 0.91 ± 0.09 (0.71-1.09) in T2DM group and statistically significant ($p<0.000$). 69% of T2DM patients and 88% of DHD patients are at high risk ($p=0.040$) (Table2).

Table 2. Characteristics for Foot Examination

Characteristics The Feet		T2DM Group (n=62)		DHD Group (n=34)		Test and P χ^2 test†
		n	%	n	%	
Heat	Normal	53	85.5	7	20.6	0.000
	Cold	9	14.5	27	76.5	
Color	Normal	58	93.5	10	29.4	0.000
	Pale	4	6.5	24	70.6	
Dorsalis Pedis Pulse	Normal	12	19.4	5	14.7	0.237
	Weak	31	50	12	35.3	
	Very weak	19	30.6	17	50	
Tibialis Posterior Pulse	Normal	12	19.4	6	17.6	0.251
	Weak	31	50	11	32.4	
	Very weak	19	30.6	17	50	
Hydration	Normal	11	17.7	5	14.7	0.040
	Dry	51	82.3	29	85.3	
Edema	Yes	9	14.5	11	32.4	0.018
	No	53	85.5	23	67.6	
Nail Cutting	Flat	3	4.8	1	2.9	0.080
	Round	30	48.4	9	26.5	
	Other	29	46.8	24	70.6	
Finger Break	Normal	38	61.3	26	76.5	0.189
	Macerated	16	25.8	7	20.6	
	Fundus	8	12.9	1	2.9	
Cracking	Yes	14	22.6	26	76.5	0.000
	No	48	77.4	8	23.5	
Callus	Yes	54	87.1	33	97.1	0.109
	No	8	12.9	1	2.9	
Foot Muscle Strength	Normal	15	24.2	5	14.7	0.006
	Decreased	31	50	9	26.5	
	Very diminished	16	25.8	20	58.8	
Hammer finger	Yes	18	29	16	47.1	0.112
	No	44	17	18	52.9	
Hallux limutus	Yes	59	95.2	32	94.1	0.322
	No	3	4.8	2	5.9	

Table 2. (continue) Characteristics for Foot Examination

		T2DM Group (n=62)		DHD Group (n=34)		Test and P
Characteristics the Foots		n	%	n	%	χ ² test‡
Hallux valgus	Yes	16	25.8	16	47.1	0.024
	No	46	74.2	18	52.9	
Foot Hygiene	Good	4	6.5	1	2.9	0.489
	Bad	24	38.7	17	50	
	Normal	34	54.8	16	47.1	
Vibration Test	Normal	19	30.6	4	11.8	0.000
	Decreased	31	50	4	11.8	
	No	12	19.4	26	76.5	
Risk Category	Low Risk	19	31	4	12	4.297
	High risk	43	69	30	88	0.040
		X ± SD /Mean rank		X ± SD /Mean rank		0.005 §
Monofilament Test :Number of Points		4.38±4.03/ 54.35 (Min:0 – Max:10)		2.38±3.67/37.84 (Min:0 – Max:10)		
ABI Index (X ± SD) (Min – max)		0.91 ± 0.09 (0.71 - 1.09)		0.76 ± 0.10 (0.59 – 1.00)		0.000

‡ χ^2 test,

§Mann-Whitney U test,

|| t test,

Discussion

In the present study, the feet health of DHD and T2DM patients were subjected to extensive physical examination through inspection, palpation, auscultation and olfaction methods. The examination included toes, toe torso and legs (Biçer and Çelik, 2016). In the study, comparisons were made between groups to evaluate foot circulation. In physical examination, the feet of DHD patients were found to be colder in terms of heat, drier in terms of hydration and fainter in color than the feet health of T2DM patients. Heat, color, coldness and paleness are findings that indicate insufficiency in peripheral vascular blood supply and circulation. In addition to this more than 80% of the patients in both groups had weak foot pulses and there was no difference between the groups (Table 1). In different studies, Doria et al. (2016) reported that foot pulses were very weak in DM patients, and no pulse could be obtained by palpation (Doria et al,2016). Van Netten et al. (2024) measured only the pulse of the dorsalis pedis with hand doppler. They found that foot pulses were weaker in DHD patients compared to other hemodialysis patients (Van Netten et al., 2024).

The main finding of this article suggests that DHD patients have a higher risk factor for developing DFU than T2DM patients (Table2). Weak foot pulses and poor circulation in DHD patients suggest that DHD patients pose a higher hazard for the development of DFU. One method that gives information about blood flow to the feet

is the Ankle-Brachial Index (ABI) (Biçer & Çelik, 2016; Doria et al., 2016; Thompson et al., 2020). Al-Nakeeb et al. (2021) stated that ABI<0.9 should be considered as peripheral artery disease (Al-Nakeeb et al., 2021; Sartore et al, 2023). Kaminski et al. (2017) indicated that vascular failure was high in DHD because ABI values of the patients were low (Kaminski et al., 2017). In the present study, the mean ABI was 0.91 in T2DM patients and 0.76 in DHD patients. The findings of the present study are parallel to literature. Since the ABI value of DHD patients is more below value, according to the other group, it could be stated that they are at much higher risk for peripheral blood circulation. Therefore, if DFU develops, it will be difficult to recover.

In the present study, DFU had previously been formed in 50% of DHD patients and 23% of T2DM patients. Recurrent DFU development rate was reported to be 12-25% in patients who had DFU previously A DFU history is a risk factor for the recurrence (Doria et al., 2016; Nural and Hindistan, 2015). In the study, 97% of T2DM patients and 74% of DHD patients did not receive foot care education. Education alone can reduce the risk of DFU by raising awareness of patients (TÜRKDİAB, 2019). With the education received by the patient, foot care and hygiene knowledge could increase, patients could be more aware of the DFU risk, DFU could be prevented, and the quality of life could be improved. The fact that most of the patients in the study did not have foot care knowledge may have caused these results. It is important for nurses to provide foot care

information to patients. Diabetic foot training should be repeated at intervals.

In the study, protective sensation of feet is evaluated. Sensation touch of feet is tested with Semmes-Weinstein 5.07 (10 grams) monofilament (Biçer and Çelik, 2016; Wexler, 2020). DHD patients had an average of 2 points and T2DM patients had an average of 4 points. The low number of points in DHD patients is an indication that their sense of touch is very weak. The vibration sensation, in the feet, was controlled through the big toe using 128 Hz diapason. (Kaminski, 2017; Özdemir and Nural, 2021; Van Netten et al., 2024). In the study, it was found that 77% of DHD patients had no sense of vibration and 50% of T2DM patients had decreased sense of vibration. Reduced sensation in the feet poses a great risk for not feeling the injuries and traumas as well as for DFU (TÜRKDİAB, 2019; Wexler, 2020). The decrease in senses in DHD patients compared to the other group may be due to the effect of diabetic nephropathy.

In the evaluation of the feet skin, 77% of DHD patients and 23% of T2DM patients had cracks in the soles of their feet. It was observed that the feet of DHD patients had more drying and cracking than T2DM patients. The difference between patient groups is approximately three times. Other studies have found that T2DM patients have more drying and cracking in their feet than other people (Kayaş et al., 2018). Cracks are associated with excessive drying of the skin on the feet and neuropathy. These crack areas are prone to DFU formation and infection development, thereby posing serious risks (Biçer and Çelik, 2016).

In this study, the foot deformities and foot muscle strength of the patients were examined. Compared to the other group, DHD patients had weaker foot muscle strength and had more foot deformities. Kayaş et al. (2018) and Doria et al. (2016) found foot deformities and muscle weakness in patients in their study. The weakening of muscle strength due to the imbalance caused by neuropathy in the muscles lead to decreased blood flow and walking imbalance. Limitation in joint movements develops as a result of thickening due to collagen glycosylation in the structures around the joint such as tendon, ligament, joint capsule, etc. Immobility of the joints and deformities in foot structures negatively affect foot health and increase the risk of DFU (Kafadar and Kemaloğlu, 2020; Van Netten, 2024). Given the damage that diabetes does to muscles and joints, it can be said that the feet of

DHD patients are more damaged. Failure to remove waste products from the body in a timely manner may have contributed to this result.

Conclusions

In terms of the results from feet examination for DFU formation, feet health of DHD patients were found to be at higher risk than those of T2DM patients. Based on the results from the physical examination, loss of touch and vibration sensations, foot deformities, very weak foot pulses, low score of ABI, history of previous ulcers, receiving DHD treatment and insufficient information regarding the foot care were found to be the factors increasing the risk. Due to this high risk, it can be stated that the main goal of feet care in DHD patients and T2DM patients should be to early intervention with frequent check-ups, use of medication, regulation of blood sugar and protect maintain foot health and educate patients about it.

Limitations

The limitation of this study are the lack of longitudinal and repetitive measurements in this study. Another limitation of the study is that some of some of the data in the study is based on patient's self-report and not observation.

Acknowledgments

I would like to thank all the patient who participated in the research.

Ethics Committee Approval: The study was approved by the Tokat Gaziosmanpaşa University Clinical Research Ethics Committee (Date: 19/06/2028 Approval no: 2018/08). Permission was granted from Hospital. Written and oral consents were obtained from the patients in order to conduct the research. In the study, the principles of the Helsinki Declaration were observed.

Author Contributions: Concept: ŞE; Design: ŞE; Supervision: ŞE; Data Collection: ŞE; Data Processing: ŞE; Analysis and Interpretation: ŞE; Literature Search: ŞE; Preparation of the manuscript: ŞE; Critical Reviews: ŞE.

Conflict of interest: The authors report no actual or potential conflicts of interest.

Financial Disclosure: The authors received no specific funding for this work.

What did the study add to the literature?

- DHD patients have very reduced protective senses, DHD patients have very poor feet circulation.
- DHD patients have a higher risk factor for developing diabetic foot ulcer than T2DM patients. DHD patients' feet health is at risk compared to DM patients.

- It is important for nurses to provide foot care information to patients. Diabetic foot training should be repeated at intervals.

References

- Al-Nakeeb AM, Tarshoby MM, Kyrillos FA. (2021) Risk factors for foot ulceration among adult patients with diabetes on chronic hemodialysis in Dakahlia Governorate, Egypt. *Journal of The Egyptian Society of Nephrology and Transplantation*, 21(1), 18-24. https://doi.org/10.4103/jesnt.jesnt_18_20
- Al-Thani H, El-Menyar A, Koshy V, Hussein A, Sharaf A, Asim M, Sadek A. (2014). Implications of foot ulceration in hemodialysis patients: a 5-year observational study. *Journal of Diabetes Research*, 1-6. <https://doi.org/10.1155/2014/945075>
- American Diabetes Association [ADA]-a. (2023). Retinopathy, neuropathy, and foot care: standards of medicalcare in diabetes—2024. *Diabetes Care*, 46(Suppl.1), 203-215. <https://doi.org/10.2337/dc23-S012>
- American Diabetes Association [ADA]-b. (2024). Chronic kidney disease and risk management: standards of medical care in diabetes—2024 *Diabetes Care*, 46(Suppl.1), 191–202. <https://doi.org/10.2337/dc23-S011>
- Biçer EK, Çelik S. (2016). Comprehensive foot examination and risk assessment for patients with diabetes. *Türkiye Klinikleri Journal of Nursing Sciences*, 8(1), 62-70. <https://doi.org/10.5336/nurses.2013-36543>
- Cheng HT, Xu X, Lim PS, Hung KY. (2021). Worldwide epidemiology of diabetes-related end-stage renal disease, 2000–2015. *Diabetes Care*, 44(1), 89-97. <https://doi.org/10.2337/dc20-1913>
- Doria M, Rosado V, Pacheco LR, Hernandez M, Betriu A, Valls J, Franch-Nadal J, Fernandez E, Mauricio D. (2016). Prevalence of diabetic foot disease in patients with diabetes mellitus under renal replacement therapy in Lleida, Spain. *BioMed Research International*, 1-8. <https://doi.org/10.1155/2016/7217586>
- Garimella PS, Wang W, Lin SF, Hymes J, Lacson JrE. (2017). Incident diabetic foot ulcers and mortality in hemodialysis patients. *Hemodialysis International*, 21,145–147. <https://doi.org/10.1111/hdi.12490>
- Giralt-López A, Vergara A, García-Carro C, Seron D, Jacobs-Cachá C, Soler MJ. (2020). Revisiting experimental models of diabetic nephropathy. *International Journal of Molecular Sciences*, 21(10),3587. <https://doi.org/10.3390/ijms21103587>
- International Diabetes Federation [IDF]. (2019). *Diabetes Atlas*, 9th Edition 2019. <https://www.diabetesatlas.org/en/sections/individual-social-and-economic-impact.html>
- Kafadar İH, Kemaloğlu CA. (2020). Diabetic foot anatomy and importance of plantigrade foot. *Türkiye Klinikleri Orthopaedics And Traumatology-Special Topics*, 13(1), 1-6.
- Kaminski MR, Raspovic A, McMahon LP, Lambert KA, Erbas B, Mount PF, Kerr PG, Landorf KB. (2017). Factors associated with foot ulceration and amputation in adults on dialysis: A cross-sectional observational study. *BMC Nephrology*, 18, 293. <https://doi.org/10.1186/s12882-017-0711-6>
- Kaminski MR, Raspovic A, McMahon LP, Strippoli GFM, Palmer SC, Ruospo M, Dallimore S, Landorf KB. (2015). Risk factors for foot ulceration and lower extremity amputation in adults with end-stage renal disease on dialysis: A systematic review and meta-analysis. *Nephrology, dialysis, transplantation*, 30(10), 1747-1766. <https://doi.org/10.1093/ndt/gfv114>
- Kayaş Y, Ertam İ, Uysal S, Şimşir İY, Öztürk AM, Taşbakan MI, Ünal İ. (2018). Evaluation of dermatological findings in diabetic foot syndrome. *FLORA*, 23(1), 8-14. <https://doi.org/10.5578/flora.66543>
- Khan NU, Lina J, Liua X, Lib H, Lub W, Zhongb Z, Zhanga H, Waqasa M, Shena L. (2020). Insights into predicting diabetic nephropathy using urinary biomarkers. *BBA - Proteins and Proteomics*, 1868;140475. <https://doi.org/10.1016/j.bbapap.2020.140475>
- Khanijou V, Zafari N, Coughlan MT, MacIsaac RJ,Ekinci EI. (2022). Review of potential biomarkers of inflammation and kidney injury in diabetic kidney disease. *Diabetes/ Metabolism Research and Reviews*, 38(6), e3556. <https://doi.org/10.1002/dmrr.3556>
- Koch EAT, Nakhoul R, Nakhoul F, Nakhoul N. (2020). Autophagy in diabetic nephropathy: a review. *International Urology and Nephrology*, 52,1705–1712. <https://doi.org/10.1007/s11255-020-02545-4>
- Liu R, Petersen BJ, Rothenberg GM, Armstrong DG. (2021). Lower extremity reamputation in people with diabetes: a systematic review and meta-analysis. *BMJ Open Diabetes Research and Care*, 9(1), e002325. <https://doi.org/10.1136/bmjdr-2021-002325>
- Nephrology Association Report, 2017. <http://www.nefroloji.org.tr/folders/file/TND-2017-Kayit-Sistemi-Verileri.pdf>.
- Nural N, Hindistan S. (2015). Examining the knowledge and attitudes of diabetic patients about foot care. *Anatolian Journal of Nursing and Health Sciences*, 18(2), 116-124.
- Özdemir VA, Nural N. (2021). Is chronic kidney disease a risk factor for foot ulcerations? *Turkish Journal of Diabetes Nursing*, 1(2),15-21. <https://doi.org/10.29228/tjdn.52794>
- Rodrigues BT, Vangaveti VN, Urkude R, Birós E, Malabu UH. (2022). Prevalence and risk factors of lower limb amputations in patients with diabetic foot ulcers: a systematic review and meta-analysis.

- Diabetes & Metabolic Syndrome: Clinical Research & Reviews, 16(2), 102397.
- Sartore G, Caprino R, Ragazzi E, Bianchi L, Lapolla A, Piarulli F. (2023). The ankle-brachial index for assessing the prevalence of peripheral artery disease and cardiovascular risk in patients with type 2 diabetes mellitus. *Nutrition, Metabolism and Cardiovascular Diseases*, 33(3), 560-567. <https://doi.org/10.1016/j.numecd.2022.11.019>
- Schembri N, Formosa C. (2022). Dialysis Treatment is an Independent Risk Factor for Foot Morbidity. *The International Journal of Lower Extremity Wounds*, 15347346221074111. <https://doi.org/10.1177/1534734622107411>
- Thompson AT, Pillay S, Aldous C. (2020). The use of ABI in screening for diabetes-related lower limb peripheral arterial disease in IDF middle-and low-income countries: a scoping review. *International Journal of Diabetes in Developing Countries*, 1-8.
- Turkish Diabetes Foundation [TÜRKDİAB]. (2019). *Diabetes Diagnosis and Treatment Guidelines 2019*, 9th Edition, Türkiye Diabetes Foundation. Istanbul.
- Van Baar MJ, van Bommel EJ, Smits M, Touw DJ, Nieuwdorp M, Reinier W, Joles JA, van Raalte DH. (2022). Whole-body insulin clearance in people with type 2 diabetes and normal kidney function: Relationship with glomerular filtration rate, renal plasma flow, and insulin sensitivity. *Journal of Diabetes and its Complications*, 108166. <https://doi.org/10.1016/j.jdiacomp.2022.108166>
- Van Netten JJ, Raspovic A, Lavery LA, Monteiro-Soares M, Paton J, Rasmussen A, Bus SA. (2024). Prevention of foot ulcers in persons with diabetes at risk of ulceration: a systematic review and meta-analysis. *Diabetes/Metabolism Research and Reviews*, 40(3), e3652. <https://doi.org/10.1002/dmrr.3652>
- Wexler DJ. (2020). Evaluation of the diabetic foot. Up to date, <https://www.uptodate.com/contents/evaluation-of-the-diabetic-foot?>
- Yürekli ŞB, Kocabaş GÜ, Mirili C, Yürekli İ, Çakır H. (2018). Is the ankle-brachial index directly related to current glycemic control in diabetic patients? *Damar Cer J*, 27(3), 117-123. <https://doi.org/10.9739/tjvs.2018.152>