T.C
YEDİTEPE UNIVERSITY
INSTITUTE OF HEALTH SCIENCES
DEPARTMENT OF NUTRITION AND DIETETICS

DIETITIAN MONITORING IN DIABETIC FOOT ULCERS: A RETROSPECTIVE STUDY

MASTER OF SCIENCE THESIS

BERK AYSAN

İstanbul-2024

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SUPERVISOR

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APPROVAL
This thesis has been deemed by the jury in accordance with the relevant articles of Yeditepe University Graduate Education and Examinations Regulation and has been approved by Administrative Board of Institute with decision dated ……. and numbered .....

DECLARATION

I hereby declare that I have written this work, which I submit as a master's thesis, without resorting to any means or assistance that would be contrary to scientific ethics and traditions. I confirm that the works I have utilized are those listed in the bibliography and that I have cited these works whenever I have used them. I solemnly affirm this declaration with my honor. I also declare that, irrespective of the time, if any situation contrary to this declaration is identified by the institute, I will bear all the ethical and legal consequences that may arise.

BERK AYSAN

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LIST OF SYMBOLS AND ABBREVIATIONS

ADA	The American Diabetes Assiciation
BUN	Blood Urea Nitrogen
CRP	C- reactive protein
DFS	Diabetic Foot Syndrome
DM	Diabetes Mellitus
DPP-IV	Dipeptidyl peptidase IV
DPP4-1	Dipeptidyl peptidase-4 inhibitor
FBG	Fasting Blood Glucose
GDPR	General Data Protecition Regulation
GLP-1A	Peptide-1 receptor agonist
IWDGF	International Working Group on the Diabetic Foot
PAD	Peripheral Artherial Disease
T2DM	Type 2 Diabetes Mellitus
TZDs	Thiazolidinediones
T. protein	Total protein
WIFI	Wound , Ischemia , Foot Infection
WHO	World Health Organization

ABSTRACT

Aysan, B. (2024). Dietitian Monitoring in Diabetic Foot Ulcers: A Retrospective Study. Yeditepe University, Institute of Health Science, Department of Nutrition and Dietetics, MSc thesis, İstanbul

This study aimed to assess the impact of nutritional therapy and follow-up on patients diagnosed with diabetic foot ulcers. Data from 255 patients at the Diabetic Foot Clinic of Bursa Medical Park Hospital were analyzed. Patients were divided into three groups: Group 1 (36 patients) with metabolic disorders referred to and visited a dietitian; Group 2 (47 patients) with metabolic disorders referred to but did not visit a dietitian; and Group 3 (172 patients) with controlled metabolism who did not visit a dietitian. In Group 1, the highest frequency of dietitian visits was twice. Mean HbA1c levels in Group 1 decreased from 9.7% to 8.1% (83% reduction), while in Group 2, it decreased from 10.4% to 8.2% (78% reduction). Fasting blood glucose (FBG) levels in Group 1 decreased from 217 mg/dL to 153 mg/dL (70% reduction), and in Group 2, from 283 mg/dL to 164 mg/dL (57% reduction). Group 1 showed a 76% increase in albumin levels, with no significant change in the other groups. CRP (C-reactive protein) levels significantly decreased in Group 1 but remained unchanged in Group 2. Post-treatment data for Group 3 were insufficient for significant results. The study concluded that visiting a dietitian positively contributed to metabolism regulation, increased albumin levels, and infection control in diabetic foot ulcer treatment. The higher frequency of dietitian visits among patients undergoing surgery may indicate their increased seriousness about their condition.

Keywords; Type 2 Diabetes, Diabetic Foot Ulcer, Dietary follow, Nutritional management

ÖZET (TURKISH)

Aysan, B. (2024). Dietitian Monitoring in Diabetic Foot Ulcers: A Retrospective Study. Yeditepe University, Institute of Health Science, Department of Nutrition and Dietetics , MSc thesis, İstanbul

Bu çalışma, diyabetik ayak ülseri tanısı konan hastalarda beslenme tedavisi ve takibinin etkisini değerlendirmeyi amaçlamıştır. Bursa Medical Park Hastanesi Diyabetik Ayak Kliniği'ndeki 255 hastanın verileri analiz edilmiştir. Hastalar üç gruba ayrılmıştır: Metabolik bozuklukları olan ve diyetisyene yönlendirilen ve ziyaret eden 36 hastadan oluşan Grup 1; metabolik bozuklukları olan ve diyetisyene yönlendirilen ancak ziyaret etmeyen 47 hastadan oluşan Grup 2; ve metabolizması kontrol altında olan ve diyetisyeni ziyaret etmeyen 172 hastadan oluşan Grup 3. Grup 1'de diyetisyen ziyaret sıklığı en yüksek iki kez olmuştur. Grup 1'deki ortalama HbA1c seviyeleri %83 azalarak %9.7'den %8.1'e düşerken, Grup 2'de %78 azalarak %10.4'ten %8.2'ye düşmüştür. Grup 1'deki açlık kan şekeri (AKŞ) seviyeleri %70 azalarak 217 mg/dL'den 153 mg/dL'ye düşerken, Grup 2'de %57 azalarak 283 mg/dL'den 164 mg/dL'ye düşmüştür. Grup 1'de albumin seviyelerinde %76 artış gözlemlenirken, diğer gruplarda anlamlı bir değişiklik olmamıştır. Grup 1'de C-reaktif protein (CRP) seviyeleri önemli ölçüde azalırken, Grup 2'de değişiklik olmamıştır. Grup 3'ün tedavi sonrası verileri anlamlı sonuçlar için yetersiz kalmıştır. Çalışma, diyetisyene gitmenin metabolizma düzenlemesine, albumin seviyelerinin artmasına ve enfeksiyon kontrolüne olumlu katkı sağladığını sonucuna varmıştır. Ameliyat geçiren hastalar arasında diyetisyen ziyaret sıklığının yüksek olması, bu hastaların durumlarına daha ciddi yaklaştıklarını gösterebilir.

Anahtar Kelimeler: Tip 2 Diyabet, Diyabetik Ayak Ülseri, Diyet Takibi, Beslenme Yönetimi

1.INTRODUCTION

Diabetic foot syndrome, as defined by the World Health Organization (WHO), is "ulceration of the foot associated with neuropathy and varying degrees of ischemia and infection." (1). Diabetic foot ulcers are divided into grades according to the depth of the ulcer and the severity of infection. Grade 0 means no ulcer but it carries risk. Grade 1 means a superficial ulcer in the outer layers of the skin. Grade 2 is a deep ulcer. Grade 3 is an ulcer with bone involvement. Grade 4 means gangrene or dead tissue is present on the front of the foot, meanwhile Grade 5 means gangrene has spread to the entire foot (2). As the nutritional status of individuals with diabetic foot ulcer syndrome worsens, ulcer severity (Wagner Classification measurement) and infection severity may increase (3). Another important factor is the glucose level. Long-term high glucose levels can increase the complications of cardiovascular disease, kidney failure, and diabetic foot ulcers, along with other complications. Hyperglycemia has an effect on blood flow and arteriosclerosis. These reasons cause lack of oxygen and nutrients at the site of the wound. It may also interrupt the wound healing process (4). In patients with chronic wounds, cellular activity and inflammation in the healing wound increase metabolic demands. Therefore, they need more energy and higher nutritional intake. Patients suffering from diabetic foot ulcers have a hypermetabolism state of the wound, as well as decreased sensitivity to insulin, increased levels of counter-regulatory hormones such as cortisol, catecholamines and glucagon due to high levels of stress, and lack of adequate energy intake, causing the body to use muscle proteins as an energy source. However, despite the need for higher energy sources and essential nutrients during wound healing, diabetic patients, especially if overweight or obese are often advised to follow low-calorie diets to better manage their glycemic index and related complications (5). In this study, medical nutrition therapy is one of the most important treatments in the management of diabetes and its complications. Nevertheless, studies on nutritional treatments and follow-up of patients diagnosed with diabetic foot ulcers are limited. Therefore, this study aims to evaluate the frequency of referral of patients diagnosed with diabetic foot ulcers to a dietician, the duration of diet follow-up of the patients, and the effect of dietitian follow-up on the course of the disease.

2.LITERATURE REVIEW

2.1 Diabetes Mellitus

Definition

According to the World Health Organization (WHO), diabetes is a chronic and metabolic disease characterized by high blood sugar levels that lead to serious damage to the heart, blood vessels, kidneys, eyes and nerves (6).

2.1.1 Etiologic Definition of Type 2 Diabetes

Type 2 diabetes mellitus (T2DM) is now associated with a higher risk due to a combination of environmental variables (obesity) and genetic factors. Nonetheless, the production and secretion of insulin may also be impacted by a number of environmental and social variables. In similar circumstances, some researchers have found that low-grade inflammation may serve as a central point connecting all of these putative triggers, contributing to the emergence of insulin resistance in recent research, and possibly serving as a sensor of the outcome of metabolic imbalance (7). Globally, individuals with diabetes comprise approximately 90% of those with Type 2 diabetes. In type 2 diabetes, hyperglycemia initially results from the body's cells failing to respond to insulin. With insulin resistance, the hormone's effectiveness decreases, leading to insulin accumulation. Over time, pancreatic beta cells, unable to meet the demand, begin to produce less insulin and become insufficient (8). Chronic hyperglycemia is a typical metabolic disease known as T2DM. Due to an increased risk of heart disease, stroke, peripheral neuropathy, kidney failure, blindness, and amputation, it is linked to a lower life expectancy. Raised fasting plasma glucose, raised 1- and 2-hour plasma glucose following an oral glucose tolerance test, obesity, and signs of impaired insulin action are the most well-known markers of increased risk for diabetes. This has two potentially harmful effects: first, defining such a complex disease affecting numerous metabolic pathways simply in terms of hyperglycemia may oversimplify the nature of the condition. Secondly, T2DM may actually encompass a heterogeneous group of hyperglycaemic disorders with multiple different mechanisms (9).

2.1.2 Prevelance

The prevalence of diabetes includes adults between the ages of 20-79 years. As well as diagnosed and undiagnosed diabetes. An estimated 537 million adults worldwide (10.5% of all adults in this age group) have diabetes. 3 out of every 4 adults with diabetes live in low- and middle-income countries. It is estimated that this number will increase to 643 million in 2030 and 783 million adults will be living with diabetes in 2045. Thus, it is estimated that the world population will increase by 20% during this period, while the number of diabetics is estimated to increase by 46%. Between 2021 and 2045, Turkey is expected to be among the top 10 countries in terms of the number of adult diabetes patients, with this number projected to exceed 13.4 million. Additionally, a comparison of data from 2011 and 2021 shows that the number of individuals with diabetes has increased from 3.5 million to 9 million. Regarding age-specific prevalence, the incidence of diabetes among individuals aged 20-79 in Turkey has risen to 14.5% (8).

2.1.3 Diabetes Mellitus Treatment

Nutrition Therapy Reccomendation for Diabetes

Diabetes management comprises healthy and regular nutrition, daily physical activity, and medication treatments. The most challenging aspect for individuals with diabetes is particularly the nutritional component. The American Diabetes Association (ADA) considers nutrition as complementary to diabetes management. It recommends that each individual with diabetes actively engage in self-management, as well as in education and planning (10).

The goals of nutrition therapy are as follows;

- Goals include achieving glycemic control (blood glucose level of 70-120 mg/dL), controlling blood pressure (<140/80 mmHg), maintaining an HbA1c level below 7%, reducing LDL cholesterol (<100 mg/dL), lowering

triglyceride levels (<150 mg/dL), maintaining HDL cholesterol within specific ranges (Men: >40 mg/dL, Women: >50 mg/dL), and progressing towards the target weight range (10).

- Approximately 80% of individuals with type 2 diabetes are classified as obese. In this context, weight control is essential. The daily caloric intake requirement mean 1,200-1,500 kcal for women, while for men, it ranges from 1,500 kcal to 1,800 kcal (10).

Macro-nutrient Intakes

Protein is a significant macronutrient for individuals with diabetes. For healthy individuals, the daily recommended protein intake varies between 1-1.5 g/kg/day. For individuals with diabetes, this range is not precisely known. ADA recommends that protein should constitute 15-20% of the diet to prevent kidney function impairment. For individuals with kidney problems, daily protein intake is limited to 0.8 - 1 g/kg/day (11).

Another important macronutrient is fats, which can constitute approximately 20-35% of the diet. However, the likelihood of cardiovascular diseases is 2-3 times higher in individuals with diabetes compared to healthy individuals. Therefore, individuals with diabetes need to pay particular attention to their daily fat intake. ADA recommends a high-carbohydrate, low-fat, and calorie-restricted diet for nutritional therapy in individuals with type 2 diabetes. However, there are alternative dietary programs that diversify the proportions of carbohydrates, proteins and fats (11).

2.1.4 Oral Antidiabetic Drugs

Diabetes mellitus is a chronic disease with increasing prevalence. Medication therapy is important for achieving optimal glycemic control and is often necessary. In current treatment, there are many oral antidiabetic medications available that serve various purposes. In cases where dietary therapy and lifestyle changes are insufficient for T2DM, oral antidiabetic drug therapy is implemented (12,13).

Oral antidiabetic medications are classified into categories based on their mechanisms of action:

- Insulin secretagogues (secretagogues): Sulfonylureas and benzoic acid derivatives

- Insulin sensitizers (reduce insulin resistance) (sensitizers): Biguanides and thiazolidinedione derivatives

- Drugs that slow the absorption of glucose: Alpha-glucosidase inhibitors

- Incretin mimetic drugs: Peptide-1 receptor agonists (GLP-1A), Dipeptidyl peptidase-4 inhibitors (DPP4-I).

Insulin Secretagogues

These drugs increase insulin secretion from pancreatic beta cells. This group includes sulfonylureas and meglitinides. Sulfonylureas increase insulin secretion and decrease hepatic glucose production while increasing peripheral glucose utilization.

Meglitinides are similar to sulfonylureas. They have a short duration of action but are rapidly absorbed. They act on potassium channels like sulfonylureas, but their kinetics are different. Another effect of this drug is that it shows the same effect as insulin injected before meals. It is used when exercise or diet is inadequate, that is, when it cannot be controlled (14).

Insulin Sensitizing Drugs

This group consists of two subgroups: biguanides and thiazolidinediones (TZDs). Biguanides can enhance insulin sensitivity at the liver level, while TZDs can do so at

the level of adipose tissue.Biguanides promote glucose utilization, facilitating the removal of glucose from the bloodstream, reducing hepatic gluconeogenesis, decreasing glucose absorption from the small intestine, and lowering plasma glucagon levels. Examples of drugs in this group include metformin and phenformin.Thiazolidinediones reduce insulin resistance to promote glycemic control. These drugs are not effective for insulin secretion but enhance insulin action in peripheral tissues. Additionally, they have been observed to increase glucose transporter translocation in muscles and immature adipocytes. In TZD therapy, decreases in serum insulin and fatty acid levels have been observed.Metformin is typically the first-line medication used in conjunction with lifestyle changes for individuals with type 2 diabetes. Metformin has been shown to have insulin-sensitizing effects in both the liver and peripheral tissues. Apart from its glucose-regulating effects, it has been found to have positive effects on endothelial functions as well (15).

Alpha-Glycosidase Inhibitor

This medication delays the absorption of complex carbohydrates in the intestine. Prolonged use is challenging due to gastrointestinal side effects. However, it has been observed to be effective in the treatment of postprandial hyperglycemia. They prevent the degradation of endogenous incretins in conjunction with the hormone Dipeptidyl peptidase IV (DPP-IV), thereby increasing the effect of the incretin hormone (12).

Incretin Mimetics (GLP-1A)

Drugs in this group, such as GLP-1A and DPP4-I, have been developed to mimic the action of incretin hormones. They act in a glucose-dependent manner, so they do not cause hypoglycemia. However, when used in conjunction with secretagogues and insulin, hypoglycemia may occur. For this reason, the initial dose of the drug should be low. Another effect of these drugs is that they may cause some weight loss (12).

2.1.5 Diabetes Mellitus Complications

When plasma glucose levels cannot be controlled in diabetes patients, various acute and chronic damages may occur in organs, tissues, and systems. These damages are considered as complications related to diabetes (16).

Acute Complications

- *Hypoglycemia*

Hypoglycemia is defined as a drop in blood glucose levels below 70 mg/dL. Hypoglycemia can occur due to insulin administration error, incorrect use of oral antidiabetic medications, high-intensity exercise, and inadequate nutrition.

- *Diabetic Ketoacidosis*

Diabetic ketoacidosis is a metabolic disorder caused by insufficient insulin secretion, leading to excessive elevation of blood glucose. Infection and discontinuation of insulin therapy are significant factors contributing to the development of this complication (17).

- *Lactic Acidosis*

Lactic acidosis is the accumulation of lactic acid in the body. When cells utilize non-glucose fuel for energy production, lactic acid production occurs. The accumulation of lactic acid in the body disrupts the balance. This condition typically affects individuals with type 2 diabetes more frequently (18).

Chronic Complications

- *Diabetic Nephropathy*

The high levels of blood sugar in diabetic patients result in damage to the capillaries, leading to impairment of glomerular function. Alongside the sugar in the blood, proteins start to be excreted in the urine. As kidney function deteriorates, the amount of urea in the blood increases, causing blood pressure to rise. Edema, particularly in the feet, begins to occur as a consequence (19).

- Diabetic Foot Syndrome

Diabetic foot syndrome is characterized by the presence of neuropathy, peripheral artery disease, and infection, leading to the development of diabetic foot ulcers. Prolonged exposure to high blood sugar levels causes damage to the blood vessels and nerves in the feet. Consequently, there is a decrease in sensation, including the ability to feel pain. Along with damage to the blood vessels, blood flow to the feet decreases. Wounds that occur on the feet can progress to ulcers (20).

- Diabetic Retinopathy

The most important factor in the development of diabetic retinopathy is the presence of diabetes. The risk of blindness is 25% higher compared to general population. It is evaluated as a whole of biochemical and physiological changes that cause microvasculature and retinal dysfunction as a result of exposure to hyperglycemia and other risk factors. As a result of this, vision loss can be summarized as edema in the macula and neovascularization of the iris (21).

2.2 Diabetic Foot

According to the World Health Organization's (WHO) definition, diabetic foot syndrome (DFS) is "the ulceration of the foot (distal to and including the ankle) associated with neuropathy, varying degrees of ischemia, and infection."(22). Diabetic

foot syndrome is one of the chronic complications of diabetes mellitus (DM). There are two significant risk factors: peripheral neuropathy and peripheral vascular diseases. It is likely to develop as a result of poor diabetes control. Additionally, several factors contribute to the development of diabetic foot syndrome. One of these factors is trauma, which triggers the development of ulcers. Sensory neuropathy reduces sensory awareness, and the failure to promptly detect trauma leads to the formation of pressure ulcers. Furthermore, poor blood flow, or ischemia, hinders wound healing. The severity of infections also increases with the weakening of the immune system (23).

- **Pathogenesis / Pathophysiology**

Diabetes mellitus is commonly associated with various complications manifesting as macro- and microvascular changes. It is estimated that approximately 15% of diabetic patients develop diabetic foot ulcers during the course of the disease. Risk factors include poor glycemic control, peripheral neuropathy, peripheral vascular disease, and immunosuppression. The underlying cause of ulceration is tissue damage (24). Diabetic patients are prone to infections due to factors such as neuropathy, vascular insufficiency, and impaired neutrophil functions. The most significant risk factor among them is peripheral neuropathy. Autonomic, sensory, and motor dysfunctions in the nerves make the foot susceptible to trauma. The resulting deformity in the foot leads to increased pressure, which subsequently causes ulcers and leads to infection. The infection initially develops superficially, then spreads to the tissues, and eventually to the bone (25). The pathophysiology of diabetic foot ulcers and soft tissue infections is associated with trauma, neuropathy, and peripheral arterial disease (PAD). Neuropathy in the foot results in deformities due to pressure while walking. When an ulcer develops, the limb is at risk of invasive infection. This risk is further increased when PAD is present, due to the heightened risk of ischemia. In the case of invasive foot infections affecting subfascial tissues, systemic antibiotic therapy and surgical debridement of the infected tissue are recommended. The goal of treatment is to heal the foot and keep the patient ambulatory (26).

2.2.1 Diabetic Foot Ulcer Prevelance

According to 2021 data, an estimated 537 million adults aged 20-79 worldwide (10.5% of all adults in this age group) have diabetes. This number is projected to rise to 643 million by 2030 and 783 million by 2045. While the global population is expected to increase by 20% during this period, the number of people with diabetes is anticipated to increase by 46%. Between 2021 and 2045, Turkey is expected to be among the top 10 countries in the world for the number of adults with diabetes, with this figure expected to exceed 13.4 million. Furthermore, comparing data from 2011 to 2021, the number of individuals with diabetes in Turkey increased from 3.5 million to 9 million. Among individuals aged 20-79, the prevalence of diabetes in Turkey has risen to 14.5%, placing Turkey first in terms of the proportion of individuals with diabetes. Globally, diabetes-related deaths are estimated to reach 6.7 million annually, which means there is one diabetes-related death every five seconds. Additionally, it is estimated that 240 million adults have undiagnosed diabetes, with approximately 90% of them living in developing countries (8). There is no study investigating the global prevalence of diabetic foot ulcers. Additionally, most studies assessing the prevalence of diabetic foot are conducted within specific regions over a certain period, representing localized populations. As a result, these studies vary in design and demographic characteristics of the populations they examine (27).The lifetime risk of developing a foot ulcer for a person with diabetes is 19-34%. Additionally, individuals with diabetes have a 15-fold increased risk of developing lower extremity amputations compared to those without diabetes.Infections develop in 50-60% of ulcers and are the primary pathological issue in diabetic feet. Among infected ulcers, 20% result in lower extremity amputations (28).

2.2.2 Classification

A classification system is necessary to accurately describe diabetic foot ulcers and guide their treatment. Various ulcer characteristics, such as location, depth, involvement, and size, are included in the classification. Additionally, the defined classification is crucial for assessing hospitalization needs, evaluating healing potential, and guiding daily care. There are several classification systems available for defining diabetic foot ulcers (29).

In 2019, the International Working Group on the Diabetic Foot (IWDGF) published a guideline. According to this guideline, it is recommended that health professionals use the SINBAD classification for communication at regional, national, and international levels, the IWDGF classification for infection, and the WIFI (Wound, Ischemia, and Foot Infection) classification for vascular assessment. In recent years, there has been ongoing research on classification systems for diabetic foot ulcers based on thermogram-based imaging, which relies on increased temperature in inflamed areas, or systems that involve loading foot images and patient risk factors into certain devices for calculation (30).

Wagner-Meggitt Classification

The first diabetic foot classification was the Wagner-Meggitt classification, defined in 1976. In the Wagner-Meggitt classification, diabetic foot ulcers are categorized based on the depth of the ulceration and the extent of gangrene. This classification system is known as the most widely used system. However, it does not include key parameters such as the vascular structure of the foot, infection, sensory loss, and other comorbidities (31). The Wagner classification has six grades. Grade 0 indicates no visible lesion, but there is a risk of ulcer development. Grade 1 describes a superficial ulcer at the skin level. Grade 2 occurs when the ulcer penetrates the skin, fat, and connective tissue but does not reach the bone. Grade 3 involves deeper tissue with conditions such as osteomyelitis, abscess, or tendonitis. Grade 4 is characterized by gangrene in the toes or forefoot. Grade 5 signifies that gangrene has progressed to the midfoot and hindfoot (32).

WIFI Classification

This classification grades the wound based on its depth and stages it according to the presence or absence of infection and ischemia. However, it does not include neuropathy or regional measurements of the ulcer. The grades range from 0 to 3, while the stages are categorized from A to D. This classification is sufficient for determining treatment options and comparing research findings (33).

SINBAD Scale

This scale consists of six rating criteria. The first one is the ulcer location. The forefoot region is scored as 0, while the hind and midfoot regions are scored as 1 point. The second criterion is the presence of ischemia. If the presence of ischemia is proven, it is also scored as 1 point. The third evaluation is the presence of neuropathy. It receives 1 point when detected in routine examinations. The fourth assessment is made based on the presence of bacterial infection, again receiving 1 point if present. The fifth scale is the size of the ulcer. If the ulcer size is larger than $1cm^2$, it receives 1 point. The final evaluation is the depth of the ulcer. If the ulcer is limited to the skin and subcutaneous tissue, it scores 0, whereas if it extends to the tendon or deeper tissue, it scores 1 point (33).

PEDIS Scale

The PEDIS classification was introduced in 2003 and revised in 2007. It developed a scale that categorizes individuals with diabetic foot ulcers into five categories: perfusion, extent, depth, infection, and sensation. These classifications are based on objective techniques that are globally accepted. These categories are considered as the pathogenesis of the development of diabetic foot ulcers. The PEDIS classification system is believed to provide a more precise and objective result compared to previous scales such as the Wagner classification and SINBAD in evaluations and predicting clinical outcomes (34).

2.2.3 Diabetic Foot Nutrition Treatment

Nutrition plays a significant role in the treatment of chronic wounds such as diabetic foot ulcers, yet it is not commonly perceived as part of standard care for patients. This negatively affects the health and quality of life of ulcer patients. Cellular activity and inflammation in chronic wounds increase metabolic demands, hence requiring more energy. Besides the hypermetabolic feature of diabetic foot ulcers, decreased insulin sensitivity, increased counter-regulatory hormones such as cortisol, catecholamines, and glucagon due to stress contribute to higher energy expenditure and utilization of muscle proteins as an energy source. For overweight and obese individuals, a diet low

in calories and carbohydrates is recommended for glycemic control and managing complications. It has been reported that patients with diabetic foot ulcers have lower energy, protein, and micronutrient intake compared to dietary reference values. Inadequate energy intake leads to muscle loss and slows down wound healing, resulting in skin or tissue loss (35). Furthermore, inadequate intake of essential nutrients involved in wound healing can exacerbate the condition of the wound and potentially lead to amputation and death (36). Wound healing can be adversely affected by both local factors such as infection in the ulcer area and systemic factors like ineffective glycemic control, vasculopathy, and nephropathy. In conditions such as pressure ulcers and venous ulcers, the importance of nutrition is significant. Inadequate nutrition can exacerbate such complications (37). Educating individuals with diabetic foot ulcers about their dietary needs and emphasizing essential nutrition sources can increase awareness and contribute to wound healing. Conscious consumption of fundamental nutrients can have a positive impact on wound healing, replacing adverse outcomes with positive ones (36). To prevent the development of these complications, laboratory data such as hemoglobin, leukocytes, C-reactive protein (CRP), serum albumin, serum creatinine, heamogloblin A1C (HbA1C) , low density lipoprotein- cholestrol (LDL-C) , high density lipoprotein- C (HDL-C), total cholesterol, triglycerides, and glomerular filtration rate are important (38).

3. MATERIAL AND METHODS

3.1 Participants

Participants who meet the inclusion criteria from 298 patients diagnosed with diabetic foot ulcer over the age of 18 who received treatment at the Medical Park Bursa Hospital Diabetic Foot Polyclinic between January 2019 and September 2023 were included in the study after their written voluntary consent is obtained. Wagner classifications, biochemical values of fasting blood glucose, HbA1c, CRP, hemogram (leukocytes), total protein, albumin, urea/creatine findings, whether they have been referred to a dietitian, information about whether patients have been followed up on a diet and information about the frequency of dietitian follow-up will be taken from the participants' files. Diabetic foot ulcers are divided into grades according to the depth of the ulcer and the severity of infection. Wagner Classification consists of six stages. Grade 0 means no ulcer but it carries a risk, Grade 1 means a superficial ulcer in the outer layers of the skin. Grade 2 is a deep ulcer. Grade 3 is an ulcer with bone involvement. Grade 4 means there is gangrene or dead tissue on the front of the foot, meanwhile Grade 5 means gangrene has spread to the entire foot.

3.1.1 Information about participants

Participants who meet the inclusion criteria from 298 patients diagnosed with diabetic foot ulcer over the age of 18 who received treatment at the Medical Park Bursa Hospital Diabetic Foot Polyclinic between January 2019 and September 2023 were included in the study after their written voluntary consent is obtained.

3.1.2 Participant Selection

Participants over the age of 18 who were diagnosed with diabetic foot ulcers and received treatment at the Medical Park Bursa Hospital Diabetic Foot Clinic between January 2019 and September 2023 were included, provided they meet the inclusion criteria. As a result of the evaluation, 255 out of 298 individuals continued to participate in the study. According to the exclusion criteria, 2 individuals with Buerger's disease, 5 individuals with hand ulcers, and 36 individuals whose data could

not be obtained were excluded from the study. The participants in this study ranged in age from 23 to 92 years, with 66.3% (n=169) being man and 33.7% (n=86) being women.

3.2 Research Design

This study included individuals over the age of 18 who were diagnosed with diabetic foot ulcers and registered at the Diabetic Foot Clinic of Bursa Medical Park Hospital. After obtaining written informed consent from the participants, the following data were collected and evaluated: Wagner-Meggitt classifications, including fasting blood glucose, HbA1C, CRP, hemogram (leukocytes), total protein, albumin, urea/creatinine levels, and whether the individuals were referred to a dietitian. The individuals included in the study were divided into three groups. In the Diabetic Foot Clinic, consultation from the endocrinology department was requested for 83 patients (33%) with metabolic disorders following orthopedic examination. Although dietary consultations were recommended for most of the patients treated by the endocrinology department, it was found that 36 individuals (43%) actually visited a dietitian (Group 1). It was determined that 47 individuals (57%) saw an endocrinologist but did not visit a dietitian (Group 2). From the 172 patients (67%) whose metabolism was under control by the Diabetic Foot Clinic, it was determined that no endocrinology and/or dietitian consultation was requested (Group 3). At Bursa Medical Park Hospital, the Diabetic Foot Clinic operates with a multidisciplinary team approach. This team is led by an orthopedic specialist and includes primary members such as a cardiovascular surgeon (46%), an infectious diseases specialist (35%), an endocrinologist (31%), and a radiologist (26%). When necessary, a dietitian (19%) is also involved in the treatment process. Additionally, the team includes a cardiologist (10%), another radiologist (9%), an internist (6%), a dermatologist (4%), a plastic surgeon (3%), a nephrologist (3%), a neurologist (3%), an ozone therapist (2%), a hematologist (1%), and a psychologist (1%).

3.3 Statistical Analyses

During the evaluation of the study findings, IBM SPSS Statistics 22 software was utilized for statistical analyses. The normality of parameters was assessed using the Kolmogorov-Smirnov test. Descriptive statistical methods (minimum, maximum, mean, standard deviation, median, frequency) were employed for data analysis, and for the comparison of quantitative data between groups, the Oneway Anova test was utilized for parameters showing a normal distribution. For parameters not following a normal distribution, the Wilcoxon signed-rank test was employed for within-group comparisons. The Chi-square test was used for comparing qualitative data. Significance was evaluated at a level of $p < 0.05$ with confidence interval %95 and %5 exceptible error.

4.RESULTS

The study was conducted with a total of 255 cases, ranging in age from 23 to 92 years, with (66.3% n=169) men and (33.7% n=86) women. The mean age was 62.72±11.50 years. The participants were evaluated under three groups.Groups were classifed as: “Group 1” has 36 individuals who were referred to a dietitian and went to the dietitian, “Group 2” has 47 individuals who were advised to a dietitian but did not go and “Group 3” has 172 individuals who haven’t gone to this two health unit.

There was no statistically significant difference in age means among the groups ($p > 0.05$). The ages of Group 1 ranged from 45 to 87 years , with a mean of 62.24±9.73. The ages of Group 2 ranged from 24 to 79 years, with a mean of 59.61±10.75. The ages of Group 3 ranged from 23 to 92 years , with a mean of 63.72±11.94.

There was no statistically significant difference in sex distribution among the groups ($p > 0.05$). In Group 1, 75% were men and 25% were women. In Group 2, 68.1% were men and 31.9% were women. In Group 3, 64% were men and 36% were women. The groups were homogeneus regarding age and sex (Table 4.1).

Table 4.1. Evaluation of Groups in Terms of Age and Sex

	Group 1 (n=36)		**Group 2 (n=47)**		**Group 3 (n=172)**		**Total (n=255)**		
	Min-Max	**Mean±SD**	**Min-Max**	**Mean±SD**	**Min-Max**	**Mean±SD**	**Min-Max**	**Mean±SD**	**p**
Age (years)	45-87	62.24±9.73	24-79	59.61±10.75	23-92	63.72±11.94	23-92	62.72±11.50	[1]0.099
Sex	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	
Men	27	75	32	68.1	110	64	169	66.3	[2]0.425
Women	9	25	15	31.9	62	36	86	33.7	

[1]Oneway ANOVA Test [2]Chi-square test

There was a statistically significant difference among the groups in terms of treatment type (p= 0.001; p < 0.05). The rate of undergoing surgery was significantly higher in Group 1 (80.6%) compared to Group 2 (48.9%) and Group 3 (39.5%). The overall rate of undergoing surgery was 47.1%. Table 2 and Figure 4.1 shows treatment types of the groups.

Table 4.2. Evaluation of Groups by Treatment Type

Type of Treatment	**Group 1 (n=36)**		**Group 2 (n=47)**		**Group 3 (n=172)**		**Total (n=255)**		
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**p**
Operated	29	80.6	23	48.9	68	39.5	120	47.1	0.001*
Non-Operated	7	19.4	24	51.1	104	60.5	135	52.9	
Chi-square test		*p<0.05							

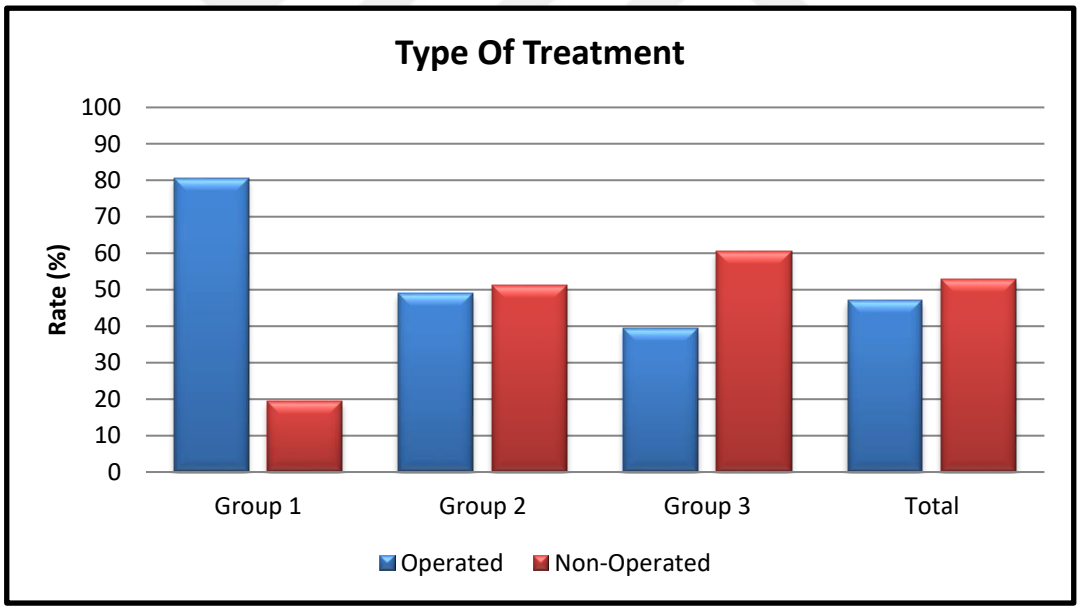

Figure 4.1 shows treatment types of the groups.

There was no statistically significant difference among the groups in terms of Wagner scores ($p > 0.05$). Overall, 13.3% of the cases were classified as W0, 8.6% as W1, 16.1% as W2, 30.2% as W3, 27.1% as W4, and 4.7% as W5. Table 3 and Figure 2 show the evaluation of groups by Wagner Classication. W5 classification were not incluced in the comperative statistics. Table 4.3 and Figure 4.2 show the evaluation of groups by Wagner Classication. W5 classification were not incluced in the comperative statistics.

Table 4.3: Evaluation of Groups by Wagner Classification

	Group 1 (n=36)		Group 2 (n=47)		Group 3 (n=172)		Total (n=255)		
	n	%	n	%	n	%	n	%	p
W0	3	8.3	8	17	23	13.4	34	13.3	
W1	2	5.6	3	6.4	17	9.9	22	8.6	
W2	2	5.6	5	10.6	34	19.8	41	16.1	0.179
W3	14	38.9	18	38.3	45	26.2	77	30.2	
W4	13	36.1	13	27.7	43	25.0	69	27.1	
W5	2	5.6	0	0	10	5.8	12	4.7	

Chi-square test

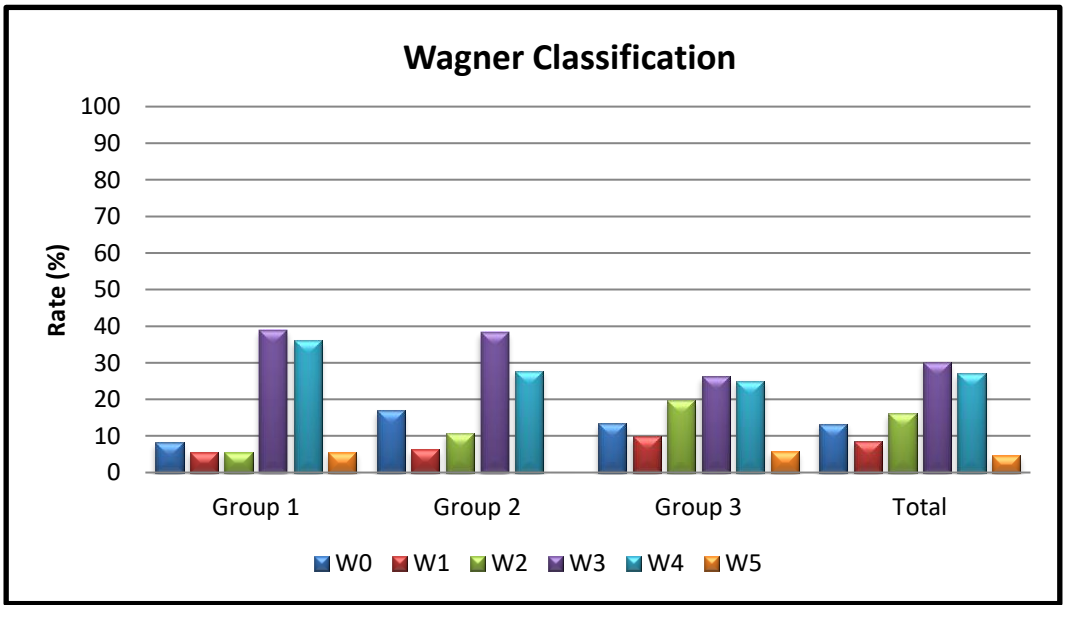

Figure 4.2 show the evaluation of groups by Wagner Classication. W5 classification were not incluced in the comperative statistics.

In all cases: There were preoperative data of 255 individuals were collected, with 237 individuals having accessible data for FBG. The mean FBG value was 210.28±116.31 mg/dL. HbA1c values were available for 223 individuals, with a mean of %8.66±2.06. CRP values were accessible for 219 individuals, with a mean of 56.83±73.01mg/L. Total protein values were available for 43 individuals, with a mean of 6.18±1.05 g/dL. Albumin values were accessible for 59 individuals, with a mean of 3.67±0.98 g/dL. BUN values were accessible for 61 individuals, with a mean of 26.62±24.88 mg/dL. Creatinine values were accessible for 65 individuals, with a mean of 1.22±0.77 mg/dL. Finally, when looking at hemogram (leukocyte) data, information for 17 individuals was available, with a mean of 9.08±3.03 K/uL. Table 4 displays the minimum, maximum, mean, standard deviation, and median values of preoperative laboratory parameters for all cases.There were 49 patients with simultaneous first and second FBG measurements. The decrease observed in the second measurement compared to the first measurement of FBG levels was statistically significant ($p= 0.001$; $p < 0.05$). There were 48 patients with simultaneous first and second HbA1c measurements. The decrease observed in the second measurement compared to the first measurement of HbA1c levels was statistically significant ($p = 0.001$; $p < 0.05$). There were 42 patients with simultaneous first and second CRP measurements. The decrease observed in the second measurement compared to the first measurement of CRP levels was statistically significant ($p = 0.001$; $p < 0.05$). There were 12 patients with simultaneous first and second total protein measurements. There was no statistically significant change observed in the second measurement compared to the first measurement of total protein levels ($p = 0.964$; $p > 0.05$). There were 16 patients with simultaneous first and second albumin measurements. The increase observed in the second measurement compared to the first measurement of albumin levels was statistically significant ($p = 0.001$; $p < 0.05$). There were no patients with simultaneous first and second measurements of urea, creatinine, and hemogram. Table 4.4 and Figure 4.3 displays the minimum, maximum, mean, standard deviation, and median values of preoperative laboratory parameters for all cases. Table 4.5 and Figure 4.3 show differences about the first and the second measurement of group 2.

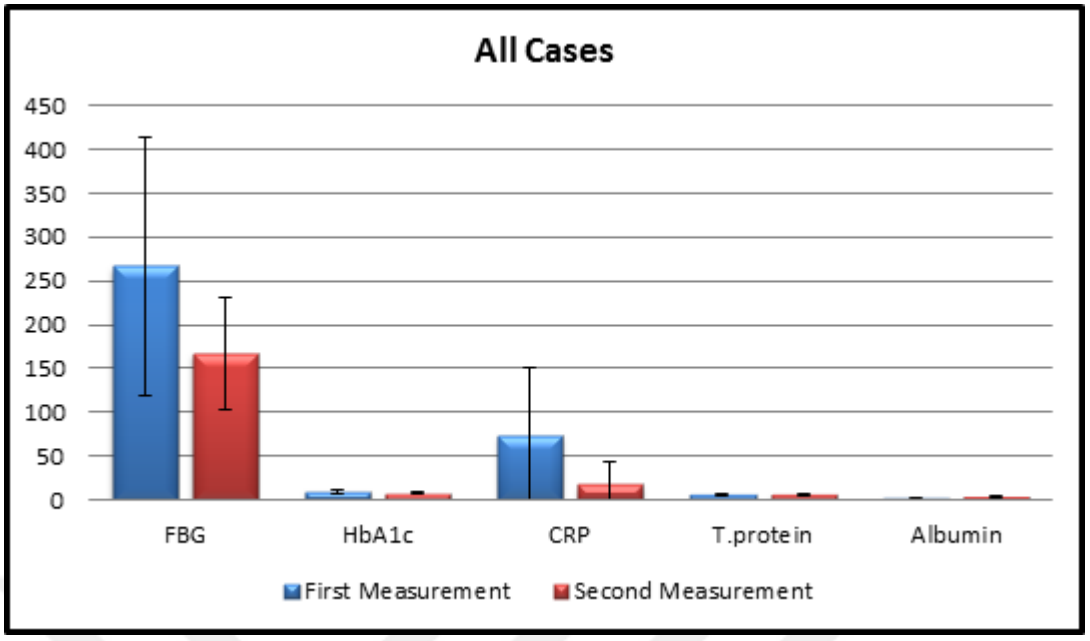

Figure 4.3 displays the minimum, maximum, mean, standard deviation, and median values of preoperative laboratory parameters for all cases..

Table 4.4.Descriptive Information on Preoperative Laboratory Parameters for All Cases

Total	**N**	**Min**	**Max**	**Mena±SD**	**Median**
FBG (mg/dL)	237	51	886	210.28±116.31	181
HbA1c (%)	223	5.14	15.9	8.66±2.06	8.55
CRP (mg/L)	219	0.1	324	56.83±73.01	23.7
T.protein (g/dL)	43	2.4	8	6.18±1.05	6.3
Albumin (g/dL)	59	1.6	7	3.67±0.98	3.6
BUN (mg/dL)	61	1.33	158	26.62±24.88	20.1
Creatine (mg/dL)	65	0.56	5.51	1.22±0.77	1.01
Leukocyte (K/uL)	17	3.86	15.3	9.08±3.03	8.2

FBG: Fasting Blood Glucose ; CRP : C-reactive protein ; T.protein: Total protein; BUN: Blood Urea Nitrogen

Table 4.5. Evaluation of Changes in Second Measurement Compared to First Measurement in All Cases

	First Measurement		Second Measurement		
All Cases	**n**	**Mean±SD (median)**	**n**	**Mean±SD (median)**	**p**
FBG (mg/dL)	49	266.47±147,3 (229)	49	167.28±63.99 (159)	0.001*
HbA1c (%)	48	9.87±2.1 (9.8)	48	8.38±2.01 (8.1)	0.001*
CRP (mg/L)	42	73.59±76.86 (50)	42	18.22±26,25 (8.1)	0.001*
T.protein (g/dL)	12	6.26±0.7 (6.4)	12	6.29±1.09 (6.7)	0.964
Albumin (g/dL)	16	3.09±0.63 (3.3)	16	3.87±0.71 (4.1)	0.001*

FBG: Fasting Blood Glucose; CRP: C-reactive protein; T.protein: Total protein ;
BUN : Blood Urea Nitrogen
Wilcoxon sign test *p<0.05

In Group 1: There were 28 patients with simultaneous first and second Fasting Blood Glucose (FBS) measurements. The decrease observed in the second measurement compared to the first measurement of FBS levels was statistically significant ($p = 0.003$; $p < 0.05$). There were 26 patients with simultaneous first and second HbA1c measurements. The decrease observed in the second measurement compared to the first measurement of HbA1c levels was statistically significant ($p= 0.001$; $p < 0.05$). There were 28 patients with simultaneous first and second CRP measurements. The decrease observed in the second measurement compared to the first measurement of C-reactive protein (CRP) levels was statistically significant ($p= 0.001$; $p < 0.05$). There were 9 patients with simultaneous first and second total protein measurements. There was no statistically significant change observed in the second measurement compared to the first measurement of total protein levels ($p= 0.674$; $p > 0.05$). Simultaneous first and second albumin measurements were conducted on 13 patients. The increase observed in the second measurement compared to the first measurement of albumin levels was statistically significant ($p= 0.002$; $p < 0.05$). There were no patients with simultaneous first and second measurements of urea, creatinine, and hemogram.Table 5 show Descriptive Information on Preoperative Laboratory

Parameters of Group 1. In Table 4.6 , minimum, maximum, mean, standard deviation, and median values of preoperative laboratory parameters for Group 1 are presented. Table 4.7 and Figure 4.4 show differences about the first and the second measurement of group 1.

Table 4.6. Descriptive Information on Preoperative Laboratory Parameters of Group 1

Group 1	**n**	**Min**	**Max**	**Mean±SD**	**Median**
FBG (mg/dL)	34	83	472	237.97±108.47	217.5
HbA1c (%)	34	6.26	13.6	9.73±1.90	9.7
CRP (mg/L)	35	0.1	319	81.24±86.45	54.0
T.protein (g/dL)	17	2.4	8	6.12±1.20	6.3
Albumin (g/dL)	22	2.1	5.1	3.42±0.76	3.4
BUN (mg/dL)	6	1.33	16.5	11.09±6.21	13.3
Creatine (mg/dL)	6	0.64	2.17	1.02±0.57	0.8
Leukocyte (K/uL)	1	6.93	6.93	6.93	6.9

FBG: Fasting Blood Glucose ; CRP : C-reactive protein ; T.protein: Total protein ; BUN : Blood Urea Nitrogen

Table 4.7. Evaluation of Changes in Second Measurement Compared to First Measurement in Group 1

	First Measurement		**Second Measurement**		
Group 1	**n**	**Mean±SD (median)**	**n**	**Mean±SD (median)**	**p**
FBG (mg/dL)	28	237.86±112.65 (217.5)	28	164.24±58.11 (153)	0.003*
HbA1c (%)	26	9.73±1.5 (9.7)	26	8,32±1.8 (8.1)	0.001*
CRP (mg/L)	28	78.95±74.13 (59.1)	28	18.89±30.48 (17.5)	0.001*
T.protein (g/dL)	9	6.29±0.64 (6.3)	9	6.4±1.23 (7)	0.674
Albumin (g/dL)	13	3.13±0.6 (3.2)	13	3.98±0.71 (4,2)	0.002*
BUN (mg/dL)	-	-	-	-	
Creatine (mg/dL)	-	-	-	-	
Leukocyte (K/uL)	-	-	-	-	

Wilcoxon sign test *p<0.05

FBG: Fasting Blood Glucose ; CRP : C-reactive protein ; T.protein: Total protein ; BUN : Blood Urea Nitrogen

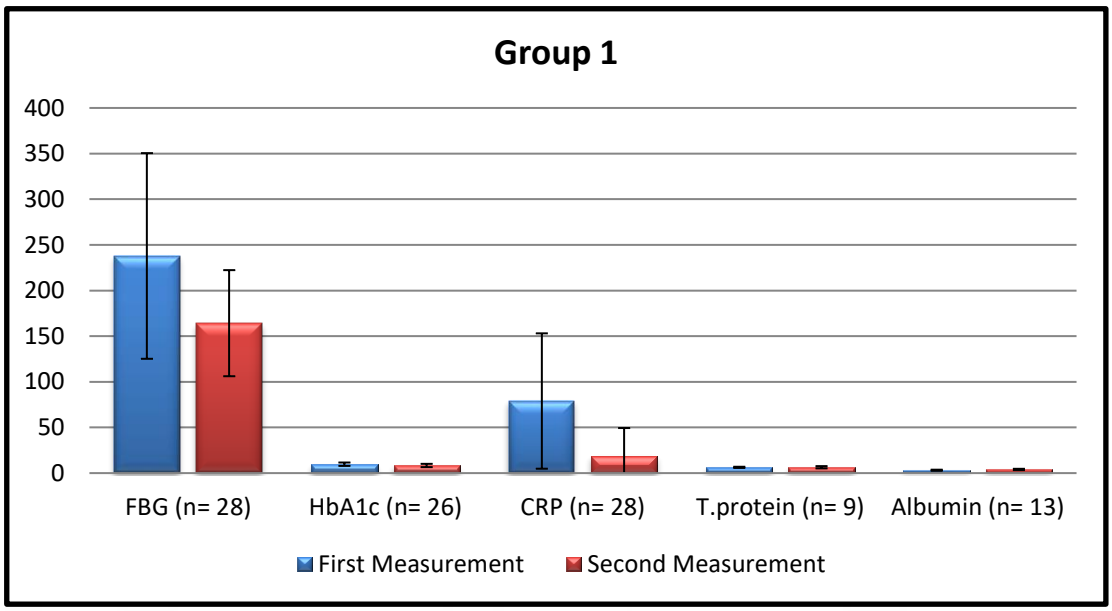

Figure 4.4.show differences about the first and the second measurement of group 1.

In Group 2: There were 20 patients with simultaneous first and second Fasting Blood Glucose (FBS) measurements. The decrease observed in the second measurement compared to the first measurement of FBS levels was statistically significant ($p= 0.001$; $p < 0.05$). There were 20 patients with simultaneous first and second HbA1c measurements. The decrease observed in the second measurement compared to the first measurement of HbA1c levels was statistically significant ($p= 0.001$; $p < 0.05$). There were 14 patients with simultaneous first and second CRP measurements. There was no statistically significant change observed in the second measurement compared to the first measurement of CRP levels ($p= 0.221$; $p > 0.05$). There were 3 patients with simultaneous first and second total protein measurements. There was no statistically significant change observed in the second measurement compared to the first measurement of total protein levels ($p= 0.593$; $p > 0.05$).There were 3 patients with simultaneous first and second albumin measurements. There was no statistically significant change observed in the second measurement compared to the first measurement of albumin levels ($p= 0.285$; $p > 0.05$). There were no patients with simultaneous first and second measurements of urea, creatinine, and hemogram. Table 8 show Descriptive Information on Pre-operative Laboratory Parameters of Group 2. Table 4.9 and Figure 4.5 shows differences about the first and the second measurement of group 2.

Table 4.8. Descriptive Information on Pre-operative Laboratory Parameters of Group 2

Group 2	n	Min	Max	Mean±SD	Median
FBG (mg/dL)	46	73	886	293.04±144.79	283.5
HbA1c (%)	43	5.84	14.46	9.97±1.91	9.5
CRP (mg/L)	42	0.1	262	57.38±69.06	18.8
T.protein (g/dL)	10	4.1	7,3	5.88±1.28	6.2
Albumin (g/dL)	13	1.6	7	3.88±1.61	3.5
BUN (mg/dL)	9	9.2	34.7	21.02±7.58	17.9
Creatine (mg/dL)	11	0.66	2.1	1.22±0.50	1.2
Leukocyte (K/uL)	2	11.34	11.41	11.38±0.05	11.4

FBG: Fasting Blood Glucose ; CRP : C-reactive protein ; T.protein: Total protein ; BUN : Blood Urea Nitrogen

Table 4.9. Evaluation of Changes in Second Measurement Compared to First Measurement in Group 2

	First Measurement		Second Measurement		
Group 2	n	Mean±SD (median)	n	Mean±SD (median)	p
FBG (mg/dL)	20	314.5±178.36 (283.5)	20	176.2±70.63 (164)	0.001*
HbA1c (%)	20	10.42±2.14 (10.4)	20	8.20±1.72 (8.2)	0.001*
CRP (mg/L)	14	62.89±83.88 (17.5)	14	16.88±15.51 (13.2)	0.221
T.protein (g/dL)	3	6.17±1.04 (6.5)	3	5.97±0.55 (6)	0.593
Albumin (g/dL)	3	2.93±0.91 (3.3)	3	3.4±0.61 (3.1)	0.285
BUN (mg/dL)	-	-	-	-	
Creatin (mg/dL)	-	-	-	-	
Leukocyte (K/uL)	-	-	-	-	

FBG: Fasting Blood Glucose ; CRP : C-reactive protein ; T.protein: Total protein ; BUN : Blood Urea Nitrogen

Wilcoxon sign test *p<0.05

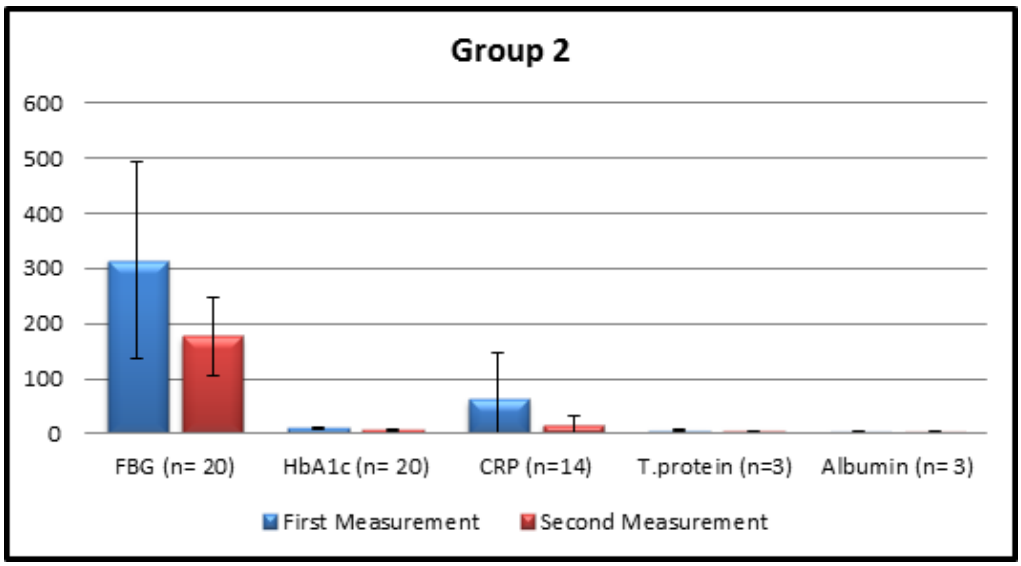

Figure 4.5 shows differences about the first and the second measurement of group 2.

In Group 3: There were 2 patients with simultaneous first and second HbA1c measurements. There was no statistically significant change observed in the second measurement compared to the first measurement of HbA1c levels (p= 0.180; p > 0.05). There were no patients with simultaneous first and second measurements of Fasting Blood Glucose (FBS), CRP, Total Protein, Albumin, Urea, Creatinine, and Hemogram. Table 4.10 presents the minimum, maximum, mean, standard deviation, and median values of preoperative laboratory parameters for Group 3.

Table 4.10. Descriptive Information on Pre-operative Laboratory Parameters of Group 3

Group 3	**n**	**Min**	**Max**	**Mean±SD**	**Median**
FBG (mg/dL)	157	51	696	180.03±93.91	150.0
HbA1c (%)	146	5.14	15.9	8.03±1.85	7.8
CRP (mg/dL)	142	0.1	324	50.64±69.76	23.2
T.protein (g/dL)	16	5.2	7.5	6.43±0.68	6.5
Albumin (g/dL)	24	2.4	4.86	3.79±0.66	4.0
BUN (mg/dL)	46	7.9	158	29.74±27.61	21.8
Creatine (mg/dL)	48	0.56	5.51	1.25±0.84	1.0
Leukocyte (K/uL)	14	3.86	15.3	8.90±3.18	8.0

FBG: Fasting Blood Glucose ; CRP : C-reactive protein ; T.protein: Total protein ; BUN : Blood Urea Nitrogen

5.DISCUSSION

A diabetic foot ulcer represents one of the devastating complications of diabetes. It is characterized by the presence of ulceration on the foot in individuals with diabetes, associated with neuropathy and/or peripheral arterial disease of the lower extremity (39). The lifetime risk of developing a diabetic foot ulcer in individuals with diabetes is between 19% and 34%. Globally, it is estimated that between 9.1 million and 26.1 million people with diabetes develop a diabetic foot ulcer complication each year. Additionally, it is estimated that one-third of the half billion individuals with diabetes worldwide will develop this complication. The incidence of foot ulcers in individuals with diabetes ranges from 4% to 19%, while the incidence in those diagnosed with neuropathy is estimated to be between 5% and 7.5% (40).

The treatment of diabetic foot ulcers varies depending on the classification of the ulcer, the status of extremity vascular supply, and the presence of infection. Given that the treatment of ulcers often involves addressing multiple comorbidities, a multidisciplinary team plays a significant role (41). In a systematic review involving 33 studies, multidisciplinary teams were evaluated, revealing the presence of endocrinologists (82%), infectious diseases specialists (37%), and internists and physical medicine rehabilitation specialists (22%). Furthermore, in 85% of the teams, two or more surgical specialists were present, including peripheral vascular surgeons (74%), orthopedic surgeons (67%), and plastic surgeons (44%) (42). In another study focused on the prevention and management of diabetic foot disease, the team was comprised of an endocrinologist, vascular surgeon, orthopedic surgeon, and cardiologist (43). According to this study, although the management of diabetic foot disease includes advice on diet and nutrition habits, a dietitian is not included as part of the multidisciplinary team.

In this study, when examining the sex and age ratios of the groups, no statistically significant difference was observed, indicating that the groups are homogeneously distributed. However, it is noticeable that men individuals are in the majority in terms of sex. In another study, it was observed that the risk of death among individuals making their first hospital visit is significantly 18% higher in men compared to women, as opposed to those without diabetic foot ulcers (44). Additionally, the 5-year

mortality rates for diabetic foot ulcer, minor amputation, and major amputation were evaluated as 30.5%, 46.2%, and 56.6%, respectively. These rates increase when concurrent with chronic kidney disease and other comorbidities. It has been observed that this condition is more lethal than many common cancers (such as breast, colon, and prostate cancer) (45). At the Diabetic Foot Clinic in Bursa Medical Park Hospital, the mortality rate among patients with diabetic foot ulcers was observed to be 23% within the data from 2018 to 2023.

Standard practices exist for managing diabetic foot ulcers. These practices include surgical debridement, wound dressings for wound control, exudate management, wound offloading, vascular assessment, infection control, and glycemic control. Once again, a multidisciplinary approach is paramount in this area (46). In this retrospective study, a significant difference in the type of treatment among the groups is observed. The surgery rates were evaluated as 86.6% for Group 1, 48.9% for Group 2, and 39.5% for Group 3. The higher surgery rate in Group 1 may be attributed to individuals undergoing surgery taking their condition more seriously and seeking consultation with a dietitian.

When evaluated in terms of Wagner scoring, there was no significant difference among the groups ($p>0.05$). This indicates that the groups were distributed homogeneously. In another study, it was observed that individuals with higher levels of HbA1c tend to have more severe diabetic foot ulcers. Most patients with Wagner 1 foot ulcers had HbA1c levels below 11.00. Half of these patients fell within the range of %7.00 to %9.00. On the other hand, individuals with Wagner 5 foot ulcers had higher HbA1c levels, with the majority of patients having levels above %11.00 (47). In diabetic individuals, the duration of diabetes is more important than age, and the risk and severity of arterial occlusion increase with each passing year. Additionally, it has been observed that a %1 increase in HbA1c raises the risk of peripheral arterial occlusion by 30% (48,49).

In this study, preoperative data of 255 individuals were collected, with 237 individuals having accessible data for FBG. The mean FBG value was 210.28±116.31 mg/dl. HbA1c values were available for 223 individuals, with a mean of 8.66±2.06 %. CRP values were accessible for 219 individuals, with a mean of 56.83±73.01 mg/dl. Total

protein values were available for 43 individuals, with a mean of 6.18±1.05 g/dl. Albumin values were accessible for 59 individuals, with a mean of 3.67±0.98 g/dl. BUN values were accessible for 61 individuals, with a mean of 26.62±24.88 mg/dl. Creatinine values were accessible for 65 individuals, with a mean of 1.22±0.77 mg/dl. Finally, when looking at hemogram (leukocyte) data, information for 17 individuals was available, with a mean of 9.08±3.03. Despite a total of 255 individuals being included in the study, not all individuals' data were available for several reasons. Firstly, HbA1c values are typically obtained every three months, and some data may have been collected outside of the data collection period, resulting in unavailability. Additionally, many individuals may have had their blood tests conducted by their family physicians, leading to the hospital not having access to their phone numbers through hospital GDPR (General Data Protection Regulation) regulations and thus being unable to access their e-Nabız records, rendering the data unattainable and ineligible for inclusion in the study.

When evaluating the biochemical data for all groups, there were 49 cases where both the first and second FBG measurements were taken simultaneously. The decrease observed in the second measurement compared to the first measurement was statistically significant ($p= 0.001$; $p<0.05$). Similarly, there were 48 cases where both the first and second HbA1c measurements were taken simultaneously, and the decrease observed in the second measurement compared to the first measurement was statistically significant ($p= 0.001$; $p<0.05$). Additionally, there were 42 cases where both the first and second CRP measurements were taken simultaneously, and the decrease observed in the second measurement compared to the first measurement was statistically significant ($p =0.001$; $p<0.05$). However, there were only 12 cases where both the first and second total protein measurements were taken simultaneously, and no statistically significant change was observed in the second measurement compared to the first measurement ($p=0.964$; $p>0.05$). Moreover, there were 16 cases where both the first and second albumin measurements were taken simultaneously, and the increase observed in the second measurement compared to the first measurement was statistically significant ($p=0.001$; $p<0.05$). Lastly, there were no cases where both the first and second urea, creatinine, and hemogram measurements were taken simultaneously. These results indicate the significant importance of treatment in diabetic foot ulcers. According to another study, HbA1c level is considered an

important factor for diabetic foot. Monitoring HbA1c levels can be considered a predictor for high-risk patients. It has been observed that HbA1c levels increase linearly with Wagner classification. However, larger-scale studies are needed to evaluate the true relationship (50). In another prospective study, participants were divided into two groups: those receiving standard diabetes and ulcer treatment with good control and those with poor control. After a 12-week comparison, it was observed that the group with good control showed better improvement in terms of fasting blood glucose, postprandial blood sugar, and ulcer area at weeks 4 and 12 (51).

When evaluated within their own groups, in Group 1, out of 36 individuals, the changes between the first and second measurements were as follows: The number of patients with both first and second measurements of FBG simultaneously was 28. The decrease observed in the second measurement (164.24±58.11) mg/dl compared to the first measurement (237.86±112.65) mg/dl of FBG was statistically significant ($p= 0.003$; $p<0.05$). Similarly, the number of patients with both first and second measurements of HbA1c simultaneously was 26. The decrease observed in the second measurement (8.32±1.8) % compared to the first measurement (9.73±1.85) % of HbA1c was statistically significant ($p= 0.001$; $p<0.05$). Furthermore, the number of patients with both first and second measurements of CRP simultaneously was 28. The decrease observed in the second measurement (18.89±30.48) mg/dl compared to the first measurement (78.95±74.13) mg/dl of CRP was statistically significant ($p= 0.001$; $p<0.05$). However, there were only 9 patients with both first and second measurements of total protein simultaneously, and no statistically significant change was observed in the second measurement (6.29±0.64) g/dl compared to the first measurement (6.29±0.64) g/dl of total protein ($p= 0.674$; $p>0.05$). Additionally, there were 13 patients with both first and second measurements of albumin simultaneously. The increase observed in the second measurement (3.98±0.71) g/dl compared to the first measurement (3.13±0.6) g/dl of albumin was statistically significant ($p= 0.002$; $p<0.05$). However, there were no patients with both first and second measurements of urea, creatinine, and hemogram simultaneously within the group. The reason for the absence of biochemical data for all patients within the group is that despite access to certain blood tests from the hospital system, data could not be accessed due to the inability to reach patients' phone numbers and the requirement of an e-Nabız records.

In another study, nutritional education interventions, when applied for at least 3 months in patients with type 2 diabetes, particularly with a combination of individualized education and diet, exercise, and psychosocial interventions, were found to be effective in significantly reducing HbA1c levels (52). In another retrospective case-control cohort study, the nutritional status of diabetic foot ulcer patients was evaluated by professional nutritionists. It was observed that individuals receiving professional support experienced a reduction in hospitalization durations, antibiotic treatment durations, and the number of surgical debridements (53).

Out of the 255 participants in the study, only 36 individuals (14%) visited a dietitian. The reasons for this low rate were attributed to several factors, including health insurance not covering dietitian fees, individuals not paying attention to their dietary habits, not associating their illnesses with nutrition, and not being willing to adhere to the dietary plans provided by dietitians. It is believed that besides economic constraints, individuals' lack of awareness about nutrition reflects on their health condition. Another study concluded that economically disadvantaged individuals with peripheral neuropathy and diabetes for over 10 years require education and counseling to improve foot care and weight loss efforts (54).

For Group 2, the number of patients with simultaneous first and second fasting blood glucose measurements was 20. The decrease observed in the second measurement compared to the first measurement was statistically significant ($p = 0.001$; $p < 0.05$). Similarly, the number of patients with simultaneous first and second HbA1c measurements was 20, and the decrease observed in the second measurement compared to the first measurement was statistically significant ($p= 0.001$; $p < 0.05$). There were 14 patients with simultaneous first and second CRP measurements. No statistically significant change was observed in the second measurement compared to the first measurement ($p= 0.221$; $p > 0.05$). For total protein measurements, there were 3 patients with simultaneous first and second measurements. No statistically significant change was observed in the second measurement compared to the first measurement ($p= 0.593$; $p > 0.05$). Likewise, there were 3 patients with simultaneous first and second albumin measurements, and no statistically significant change was observed in the second measurement compared to the first measurement ($p= 0.285$; $p>$

0.05). There were no patients with simultaneous first and second measurements for urea, creatinine, and hemogram.

This group has been referred to the endocrinology department due to metabolic disorders. Despite the endocrinologist's referral of all these patients to a dietitian, this group did not visit the dietitian. The reasons for this, as mentioned above, include the lack of nutritional education, lack of insurance coverage, and individuals' lack of awareness of the importance of seeing a dietitian.

For Group 3, there were only 2 patients who had both first and second HbA1c measurements. There was no statistically significant change observed in the second measurement compared to the first ($p = 0.180$; $p > 0.05$). There were no patients who had simultaneous measurements of FBG, CRP, total protein, albumin, BUN, creatinine, and hemogram in both first and second instances. When considering only the preoperative laboratory parameters of individuals representing this group, there were 157 patients who had FBG measurements, with an mean of (180.03±93.91) mg/dl. The number of patients with HbA1c measurements was also 146, with an mean of (8.03±1.85) %. For CRP measurements, there were 142 patients, with an mean of (50.64±69.76) mg/l. The number of patients with total protein measurements was 16, with an mean of (6.43±0.68) g/dl. For albumin measurements, there were 24 patients, with an mean of (3.79±0.66) g/dl. The number of patients with BUN measurements were 46, for creatinine it was also 48, and for hemogram (leukocyte), it was 14, with means of (11.09±6.21) mg/dl, (1.02±0.57) mg/dl, and (6.93) K/uL, respective. When looking at this group, it's observed that the majority of the 172 patients do not have metabolic disorders and do not seek support from a dietitian or an endocrinologist. All patients in this group were evaluated by an Orthopedics specialist at the Diabetic Foot Clinic. Although it is observed that individuals in the hospital system did not go to either an endocrinologist or a dietitian, it is thought that some patients may have visited an endocrinologist and dietitian at another hospital. Additionally, within the group, it was observed that the majority (60.5%) were treated conservatively without surgery. This implies that conservative measures were taken, such as wound care for those with wounds and medical treatment for those without wounds. Due to insufficient data, post-treatment blood tests could not be included in the study. In a another study, conservative treatment involving prolonged culture-guided use of

parenteral or oral antibiotics for patients hospitalized due to diabetic foot ulcers or suspected osteomyelitis resulted in success without amputation in the majority of cases (63%) (55).

In conclusion, after the treatment regulated by the endocrinologist, the group of patients who were recommended and visited the dietitian (Group 1) showed a decrease in the mean HbA1c from %9.7 to %8.1, representing a 83% reduction, while the group that did not visit the dietitian (Group 2) had an mean decrease from %10.4 to % 8.2, representing a 78% reduction. For Group 3, sufficient data was available before the procedure, but not afterwards. The FBG level decreased by 70% from 217.5 mg/dL to 153mg/dL in the group that visited the dietitian (Group 1), while it decreased by 57% from 283.5 mg/dL to 164 mg/dL in the group that did not visit the dietitian (Group 2). For Group 3, sufficient data was available before the procedure, but not afterwards. While there was no significant change in total protein levels in Groups 1 and 2, there was a significant increase of 76% in albumin levels from 3.2 g/dL to 4.2 g/dL in Group 1. No significant change was observed in Group 2. For Group 3, sufficient data was available before the procedure, but not afterwards. Although there was a significant decrease in the mean CRP level in Group 1, no significant change was observed in Group 2. For Group 3, sufficient data was available before the procedure, but not afterwards. The significant decrease in CRP levels in Group 1 can be attributed to the higher pre-procedural mean CRP level, indicating potentially more severe infections in these patients. Furthermore, the dietitian-regulated diet appears to have a positive effect on regulating malnutrition, wound healing, and reducing infection. The increase in the rate of visiting the dietitian with an increase in infection in diabetic foot ulcers may be due to patients taking their condition more seriously. Significant differences were found among the groups in terms of treatment type. After the treatment was regulated by the endocrinologist, the rate of undergoing surgery was 80% in the group of patients who were recommended and visited the dietitian (Group 1), while it was 48.9% in the group who did not visit the dietitian despite the endocrinologist's recommendation (Group 2), and 47.1% in the group who did not visit either the endocrinologist or the dietitian (Group 3). The high rate of undergoing surgery along with the high rate of visiting the dietitian in Group 1 can be attributed to patients taking their condition more seriously and thus following the recommended dietary guidelines.

This study demonstrates that dietitian follow-up has a positive impact on multidisciplinary care. However, considering that only 14% of the 255 individuals consulted a dietitian, this rate is quite low. The importance of nutrition in diabetes treatment is significant. Therefore, providing nutritional education to individuals will lead to much greater differences. It is believed that repeating this study prospectively with future studies will yield more meaningful results.

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7. CURRICULUM VITAE

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Education

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University	Nutrition And Dietetics	TC.Yeditepe University	2022
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